UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

JUN 11 2002

In Reply Refer To:
SWR-01-SA-6116:JSS

James N. Seiber, Director
United States Department of Agriculture
Pacific West Area, Western Regional Research Center
Agricultural Research Service
800 Buchanan Street
Albany, California 94710-1105

Dear Director Seiber:

This document transmits the National Marine Fisheries Service's (NMFS) biological opinion based on our review of the proposed Water Hyacinth Control Program for 2002, encompassing the waters of the Sacramento-San Joaquin Delta and the anadromous waters of the San Joaquin River, its tributaries and its effects on the endangered Sacramento River winter-run chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run chinook salmon (*O. tshawytscha*), and threatened Central Valley steelhead (*O. mykiss*), in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq*). Your letter of December 14, 2001, requesting formal consultation was received on December 19, 2001.

This biological opinion (Enclosure 1) is based partially on information provided by the applicants to NMFS in their biological assessment, during consultation meetings, phone conversations and electronic and written correspondences with NMFS, which are detailed in the consultation history. Additional sources of information were also utilized in the development of this biological opinion. A complete administrative record of this consultation is on file at the Sacramento, California, field office of NMFS.

This biological opinion concludes that the U.S. Department of Agriculture-Agriculture Research Service (USDA-ARS) and the State of California, Department of Boating and Waterways' Water Hyacinth Control Program in 2002 is not likely to jeopardize the continued existence of the Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon and Central Valley steelhead, nor is it likely to result in adverse modification of their critical habitat. Because NMFS believes there will be some incidental take of Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon, and Central Valley steelhead, as a result of the program operations, an incidental take statement is also attached to the biological opinion. This statement includes several reasonable and prudent measures that NMFS believes are necessary and appropriate to reduce, minimize and monitor project impacts. Terms and conditions to implement the reasonable and prudent measures are presented in the take statement and must be adhered to in order for the take exemptions of section 7 (o)(2) of the ESA to apply (16 U.S.C. 1536 (o)(2).

The biological opinion also provides several conservation recommendations for Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon and Central Valley steelhead that include the use of adaptive management procedures that will decrease the risk of detrimental impacts on listed salmonids, and studies designed to explore alternative control measures on water hyacinth to (1) reduce risks to juvenile salmonid rearing and adult/juvenile migration within the Sacramento/San Joaquin Delta, (2) reduce the dependence on chemical control methods in the Delta, and (3) focus on a long-term solution for the control/management of water hyacinth in the Sacramento/San Joaquin Delta.

This document also transmits NMFS's essential fish habitat (EFH) Conservation Recommendations for chinook salmon (*Oncorhynchus tshawytscha*) as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) as amended (16 U.S.C. 1801 et seq.; Enclosure 2).

The USDA-ARS has a statutory requirement under section 305(b)(4)(B) of the MSFCMA to submit a detailed response in writing to NMFS that includes a description of the measures proposed for avoiding, mitigating, or offsetting the impact of the activity on EFH, as required by section 305(b)(4)(B) of the MSFCMA and 50 CFR 600.920 (j) within 30 days. If unable to complete a final response within 30 days of final approval, the USDA-ARS should provide a interim written response within 30 days before submitting its final response.

If you have any questions regarding this response, please contact Jeffrey Stuart in our Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814. Mr. Stuart may be reached by telephone at (916) 930-3607 or by Fax at (916) 930-3629.

Sincerely,

Jane H. Lecky

for Rodney R. McInnis
Acting Regional Administrator

Enclosures (2)

cc: Lars Anderson, Lead Scientist
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NMFS- Sacramento Administrative File

Endangered Species – Section 7 consultation

BIOLOGICAL OPINION

Agency:	U.S. Department of Agriculture, Agricultural Research Service, Pacific Wet Area, Western Regional Research Center
Activity:	Water Hyacinth Control Program for 2002
Consultation Conducted By:	Southwest Region, National Marine Fisheries Service
Date Issued:	JUN 11 2002

I. CONSULTATION HISTORY

The California Department of Boating and Waterways (DBW) intends to implement the proposed Water Hyacinth Control Program (WHCP) for 2002 at numerous infestation sites throughout the San Joaquin – Sacramento Delta (Delta) and within several of its tributaries in the San Joaquin Valley. The WHCP was initiated in 1982 with the amendment of the California Harbors and Navigation Code by SB 1344 designating the California Department of Boating and Waterways as the lead state agency for controlling water hyacinth in the Delta, its tributaries and Suisun Marsh. The United States Department of Agriculture, Agricultural Research Service (USDA-ARS) is the lead federal sponsor.

Anticipating the conclusion of the 2001 application season covered under the previous biological opinion (June 8, 2001), the USDA-ARS requested formal Section 7 consultation in a letter dated December 14, 2001 and received by the National Marine Fisheries Service (NMFS) on December 19, 2001. The USDA-ARS wishes to continue the WHCP for the 2002 season. The USDA-ARS had previously sent a biological assessment for the proposed WHCP for the 2001 spraying season on February 15, 2001 and a formal request for Section 7 consultation on April 16, 2001. The USDA-ARS received a Biological Opinion from NMFS covering the 2001 spraying season on June 8, 2001, which expired on December 31, 2001.

On January 18, 2002, a meeting was held at the NMFS Sacramento Field Offices to discuss the consultation of the WHCP for 2002. In attendance were Lars Anderson of USDA-ARS, Tim Artz, Julie Owen, Marcia Carlock, Jeff Schwammel, and Dan Waltz of DBW, Chris Tartara of NMFS-Santa Rosa, and Shirley Witalis and Jeff Stuart of NMFS-Sacramento. This meeting discussed timelines and operational procedures of the WHCP. A second meeting was scheduled for February 22, 2002 between Mike Aceituno of NMFS-Sacramento and representatives from the DBW and the USDA-ARS.

On January 30, 2002, the WHCP Annual Report for 2001 Application Season (volumes 1 and 2) was received in the NMFS-Sacramento Field Office. This annual report included the biotic and water quality data required by the National Pollutant Discharge Elimination System Permit (NPDES permit), and the U.S. Fish and Wildlife Service and National Marine Fisheries Service Biological Opinions.

On February 26, 2002 an e-mail from Marcia Carlock, DBW, informed NMFS that a letter from the California Department of Pesticide Regulations (CDPR) was in transit that would clarify issues concerning the interpretation of pesticide labeling information from the previous year's biological opinion. This letter from the CDPR arrived on February 28, 2002 and was signed by one Victor B. Acosta, Program Specialist in the Enforcement Branch of the CDPR.

On February 28, 2002, Jeffrey Stuart of NMFS requested a map of application sites in the Delta from Julie Owen of DBW. An electronic version was e-mailed on March 1, 2002.

On March 11, 2002, Jeff Schwammel of DBW requested to set up a meeting between NMFS, USDA-ARS and DBW to discuss the Water Hyacinth and Egeria densa biological opinions. After several e-mail exchanges, the meeting was set for April 11, 2002 at the Sacramento Field Office of NMFS.

On April 11, 2002 a meeting between Jeff Stuart of NMFS, Lars Anderson of USDA-ARS and Tim Artz, Marcia Carlock, Jeff Schwammel, Julie Owen, and Dan Waltz of DBW took place in the NMFS-Sacramento Field Office. Discussions of the Reasonable and Prudent Measures (RPM's) took place. Areas for early spraying were discussed and agreed upon.

On April 16, 2002 Jeff Schwammel provided a followup e-mail and phone call clarifying the concentration of 2,4-D permitted to be present in the receiving waters according to the NPDES permit. An e-mail from Jeff Schwammel on April 26, 2002 stated the new concentration limits for 2,4-D in the new NPDES General Permit that DBW applied for.

On April 23, 2002, DBW sent GIS maps of the early spraying zones for the Water Hyacinth Control Program, as discussed in the meeting of April 11, 2002.

A complete administrative record of this consultation is on file at the NMFS Sacramento Field Office.

II. DESCRIPTION OF THE PROPOSED ACTION

Introduction

The DBW requested the USDA-ARS to act as the federal nexus partner to implement the WHCP and initiate formal consultation with NMFS pursuant to Section 7 of the Endangered Species Act. The USDA-ARS in fulfillment of its directive to control and eradicate agricultural pests has contracted with the DBW to conduct research activities in association with the control program and to provide guidance in its implementation. The USDA-ARS and DBW propose to control the growth and spread of water hyacinth (*Eichhornia crassipes*) in the Delta with the aquatic herbicides Weedar® 64 and Rodeo® using an adaptive management approach. The objectives of the WHCP are to: (1) limit future growth and spread of water hyacinth in the Delta; (2) improve boat and vessel navigation in the Delta; (3) utilize the most efficacious methods available with the least environmental impacts; (4) prioritize navigational, agricultural, and recreational sites with a high degree of infestation; (5) employ a combination of control methods to allow maximum flexibility; (6) improve the WHCP as more information becomes available on control methods used in the Delta; (7) monitor results of the WHCP to fully understand impacts of the WHCP on the environment; (8) improve shallow-water habitat for native fish species by controlling water hyacinth; (9) decrease WHCP control efforts, if sufficient efficacy of water hyacinth treatment is realized; and (10) minimize use of methods that could cause adverse environmental impacts.

Portions of the Sacramento-San Joaquin River Delta and the lower sections of tributaries to the San Joaquin River are listed as regions, which may contain the following listed species:

- Central Valley Steelhead ESU (*Oncorhynchus mykiss*)- *threatened*
- Central Valley spring –run chinook salmon ESU (*O. tshawytscha*)-*threatened*
- Sacramento River winter-run chinook salmon ESU (*O. tshawytscha*) – *endangered*

In addition to the listed species, portions of the Sacramento- San Joaquin Delta have been designated as critical habitat for the Sacramento River winter-run chinook salmon and Central Valley spring-run chinook salmon. Critical habitat for the Central Valley steelhead encompasses the entire Delta and includes reaches of the Mokelumne, Cosumnes, Calaveras, Stanislaus, Tuolumne, and Merced Rivers, and all other waters accessible to anadromous fish.

Action Area

The Water Hyacinth Control Program (WHCP) includes portions of nine counties which encompass much of the Sacramento-San Joaquin Delta and its upland tributaries. The nine counties are: Contra Costa, Fresno, Madera, Merced, Sacramento, San Joaquin, Stanislaus, and Yolo. Merced and Fresno counties will be treated by the agricultural commissions of those counties under the direction of the DBW. The DBW will conduct the program in the other seven counties. The general boundaries for the treatment area in the delta and its tributaries are as follows:

- West up to and including Sherman Island, at the confluence of the Sacramento and San Joaquin Rivers;
- North on Morrison Creek up to the southern boundary of Sacramento, plus waters within Lake Natoma;
- South along the San Joaquin River and Kings River to Mendota, just east of Fresno;
- East along the San Joaquin River to Friant Dam on Millerton Lake;

- East along the Tuolumne River to La Grange Reservoir; below Don Pedro Reservoir;
- East along the Merced River to Merced Falls, below Lake McClure.

Within the project area are 307 possible treatment sites which average between one and two miles in length. Each year, sites will be prioritized after DBW crews complete a spring survey and determine which sites will be of the greatest concern. Such sites will generally have the greatest impacts to navigation, create extensive obstructions to pumping facilities, or have high levels of infestation. Daily treatment sites will be determined by priority ranking and the prevailing environmental conditions (wind, current, weather, and tides) as well as the location of local agricultural crops, native vegetation, potable water intakes and wildlife. Thus, the locations that are sprayed can change rapidly on a day to day basis. Applications of chemical herbicides are expected to result in only localized increases in the chemical residue concentration in the receiving waters. The concentration of these chemical compounds will decrease in the waters of the Delta as they are diluted by tidal and river current flows. Chemical concentrations will eventually reach negligible levels as time and distance increases from the application point.

Daily Protocol

The proposed WHCP treatment season in 2002 would extend from approximately April 1 through October 15. Four crews, each consisting of a Specialist and Technician, would carry out the spraying of herbicides in an assigned region of the Delta. Spraying would be conducted five days a week, with each team spraying about 25 acres per day in total, at one to three sites in a given day. The maximum area that could be treated in a day could range as high as 50 acres a day in the summer, when crews work overtime and weather and tidal conditions are conducive to treatment. A Field Supervisor would manage daily operations from the DBW Field Office in Stockton, California. The Supervisor would be responsible for determining daily spraying needs and assign teams to sites based on local conditions, available personnel, and equipment resources. The field Supervisor will also assure that the Notice of Intent (NOI) requirements are met by reporting the locations of the treatment sites to the respective county Agricultural Commissioner no later than the Friday prior to the week of treatment. The application of herbicides will be conducted with hand held sprayers operated from 19 to 21 foot aluminum air or outboard boats. The boats are equipped for direct metering of herbicides, adjuvants and water into the pump system of the spraying unit. The herbicide/ adjuvant mixture will be sprayed directly onto the floating mats of water hyacinth. Waste products, including both active and inert components of the herbicidal mixtures, degraded components of the herbicidal mixtures and dead and decaying vegetable matter, would be left to sink to the bottom or be carried downstream by the river and tidal currents. Operating protocols will prohibit treatments when wind conditions exceed a maximum threshold (10 mph) or water flow or wave action is excessive.

The DBW will follow the California Department of Pesticide Regulation procedures for pesticide application. Restricted Use Permits from the county agriculture commissioners relevant to the control program will be obtained prior to the initiation of the spraying program. Monitoring protocols for water quality and pesticide concentrations in treated water bodies will be strictly adhered to. These were imposed by the State Water Resources Control Board as part of the conditions for issuance of the National Pollution Discharge Elimination System (NPDES) Permit for the WHCP.

Monitoring Program

Pre-treatment measurements of dissolved oxygen (DO) will be taken daily at each site to determine if ambient environmental conditions are sufficient for the treatment to occur. Measurements of herbicidal chemical concentrations and water quality parameters will be taken at three different times during the spraying season (late spring, mid-summer and early fall) at predetermined sample sites to determine if field conditions are environmentally safe. The sample sites will reflect four different water types (tidal, slow-flowing, fast-flowing and dead-end sloughs) with two replicate sites per water type. The representative sites will be the largest sites available in their respective category for water types. Water samples will be taken both before and after treatment of the sample site.

Natural History of Water Hyacinth

The water hyacinth (*Eichhornia crassipes*) is a non-native invasive free-floating aquatic macrophyte belonging to the South American pickerelweed family (*Pontederiacea*). It is considered to be one of the most invasive species worldwide, having been reported in 56 countries worldwide (Holm *et al* 1977; Gopal and Sharma 1981).

Water hyacinth was first reported in California in a Yolo County slough in 1904 (Prokopovich *et al* 1985). The plant spread gradually through the Delta and by the late 1970's had covered nearly 1,000 acres and 150 miles of the 700 miles of waterways in the Delta (U.S. Army Corps of Engineers 1985). The spread of water hyacinth in the Delta was probably inhibited by the cool winters and occasional freezes that occur in the Central Valley, which can kill or severely retard growth of the water hyacinth (Holm *et al* 1977).

Water hyacinth grows in wetlands, marshes, shallow water bodies, slow moving waterways, lakes, reservoirs, and rivers. The plants often form large, thick mats that are monospecific in nature. Mats can reach dimensions that can block waterways and impede navigation, agricultural practices and pursuit of recreational activities. Dense mats can also serve as breeding grounds for mosquitoes, which can increase the possibility of vector born diseases in surrounding areas (Savage *et al* 1990; Meyers 1992; Rodriguez *et al* 1993; and Manguin *et al* 1996). During high wind or river flow conditions, small floats of water hyacinth often break off from the larger mats and colonize new areas. Water hyacinths are tolerant of fluctuations in water levels, seasonal flow velocities, and extremes of nutrient availability, pH, toxicants, and temperatures.

The water hyacinth growth cycle starts in spring when overwintering plants (old stem bases) initiate new growth by producing daughter plants. The minimum growth temperature is 54^0 F, optimal growth temperatures are reached at $77\text{-}86^0$ F and maximum growth temperature is reached at $92\text{-}95^0$ F. The daughter plants increase in number during spring and summer until the maximum biomass is reached in September. When the density of the mats has reached its maximum, individual plants begin to increase in size, crowding out smaller plants. This decreases the overall number of plants in the mats, while still maintaining high biomass. Water hyacinth grows faster than any other tested plant (Wolverton and McDonald 1979) and can double their numbers in as little as 6 days (Mitchell 1976). During late summer and early fall, the plants reach their full bloom. By late fall, the flowers and leaves begin to die back, and by January most of the plants have gone dormant. Water hyacinths are not very tolerant to freezing conditions, and cold climates limit their northern range. Leaves can regrow after moderate freezing, but plants do not survive hard freezes or ice conditions.

Problems Associated with Water Hyacinth Infestation

Typically, aquatic vegetation plays an important, beneficial role in the functioning of an aquatic ecosystem. Aquatic vegetation produces oxygen through photosynthesis that leads to an elevation of ambient dissolved oxygen levels in the water column. Macrophytes provide shelter and habitat for invertebrates and juvenile fish whether they are rooted in the substrate or are free floating. Macrophytes also provide substrate for periphyton (algae, fungus, and microflora) to grow on which in turn provides food resources for grazing invertebrates. These invertebrates then provide the basis for the food resources of higher trophic levels, such as fish. Aquatic plants also enhance the cycling of nutrients and minerals in the aquatic ecosystems they are part of. This is done by incorporating them into the plant tissue, which then serves as a nutritional substrate for herbivores or as a nutrient source for bacteria and fungi during their decay. Native aquatic plants are co-evolved with the other flora and fauna in their ecosystems and thus are in equilibrium with the other components of the ecosystem.

Non-native invasive species are those plants or organisms, which have been introduced into an ecosystem in which they have not evolved. These species do not have the checks and balances on their numbers and range that native species have and are likely to adversely affect native species in the invaded ecosystem. Water hyacinth is such a species. The infestation of the delta with water hyacinth has resulted in several negative impacts on this ecosystem. The increased biomass of water hyacinth has resulted in nighttime depletion of dissolved oxygen through increased levels of plant respiration, particularly during periods of elevated water temperatures. The extensive coverage of water hyacinth mats have excluded numerous species of submerged native plants by shading-out these plants or smothering emergent plants that become surrounded by the mats. Likewise, the extensive mats have created zones of hypoxic or anoxic water conditions due to extensive plant respiration and lack of water-air interface mixing. These conditions have altered the normal assemblages of invertebrate and vertebrate species normally found in ecosystems without the water hyacinth (Baily and Litterick 1993; Toft 2000; CALFED Vol. 1 ERP 2000). Water hyacinths can also lead to abiotic changes in the ecosystem such as accretion of sediment and organic detritus under the mats due to reductions of water flows through the infested sites. Likewise, the ability of the water hyacinth to absorb vast amounts of nutrients and minerals through its extensive root structure can lead to the formation of nutrient sinks in the infested zones. These sinks essentially remove these nutrients from the ecosystem due to the inability of native organisms to feed on the water hyacinth, or survive in the conditions created by the water hyacinth.

Water Hyacinth Control

The DBW was designated in 1982 as the lead agency for the implementation of a water hyacinth control program in the Delta, its tributaries and the Suisun Marsh with passage of SB 1344. The DBW initiated the WHCP in 1983 testing various methods for controlling water hyacinth in the Sacramento-San Joaquin Delta over the last seventeen to eighteen years. These methods employed chemical herbicides with adjuvants to enhance the herbicide's effectiveness, mechanical removal of the plant from waterways, and biological control of the plant using naturally occurring host-specific consumers. The preferred method was the application of herbicides to the floating mats of water hyacinth.

The DBW selected three registered aquatic herbicides for the control of water hyacinth in the Delta. The herbicides are typically used with one or more of five different adjuvants, compounds that act as surfactants and drift inhibitors. The compounds are listed and described below:

Herbicides

1.) Weedar 64® (active ingredient: 2,4-Dichlorophenoxyacetic acid, dimethylamine salt). EPA Registration Number 71368-264.

2.) Rodeo® (active ingredient: glyphosate). EPA Registration Number 524-00343.

3.) Reward® (active ingredient: diquat dibromide). EPA Registration Number 10182-404

Adjuvants

1.) Placement® (active ingredients: amine salts of organic acids, aromatic acid, aromatic and aliphatic petroleum distillates) California State Registration 2935-50163-AA.

2.) R-11® (active ingredients: alkyl aryl polyethoxylates compounded silicone and linear alcohol). California State Registration 2935-50142-AA.

3.) Agri-Dex® (active ingredients: paraffin base petroleum oil and polyoxyethylate polyol fatty acid esters). California State Registration 5905-50017-AA.

4.) Bivert® (active ingredients: amine salts of organic acids, aromatic acid, and aromatic and aliphatic petroleum distillates).

5.) SurpHtac® II (active ingredients: polyoxyethylated (6) decyl alcohol, 1-aminomethanamide dihydrogen tetraoxosulfate).

The DBW estimates that it will use approximately a maximum of 900 gallons of herbicide on 500-1,000 acres of Delta waterways for 2002.

WHCP Adaptive Management

The DBW proposes to employ an adaptive management strategy for conducting the WHCP. This strategy will allow the DBW to re-evaluate its project protocol as new data and information becomes available that enhances the efficiency of the program or minimizes its environmental impact. The proposed adaptive management strategies include:

- Evaluating the need for control measures on a site by site basis;
- Selecting appropriate indicators for pre-treatment environmental monitoring;
- Monitoring indicators following treatment and evaluating data to determine program efficacy and environmental impacts;
- Support ongoing research to explore the impacts of the WHCP and alternative control methodologies;
- Report findings from monitoring evaluations and research to regulatory agencies and stakeholders;
- Adjust program actions, as necessary, in response to recommendations and evaluations by regulatory agencies and stakeholders.

Physio-chemical Properties of Program Herbicides and Adjuvants

The mode-of–action is the overall manner in which a herbicide affects a plant at the tissue or cellular level. Herbicides can be organized into those, which are applied to foliage, and those, which are applied almost strictly to soil. The foliar groups are further divided into three categories according to movement through the plant:

- Symplastically translocated (source to sink, capable of downward movement in plant),
- Apoplastcially translocated (capable of upward movement in plant),
- Those, which do not move appreciably (kills very quickly on contact).

Plants are complex organisms with well-defined structures and numerous biochemical processes that are necessary for life. Some of these vital metabolic pathways include photosynthesis, amino acid and protein synthesis, fat synthesis, pigment synthesis, nucleic acid synthesis, oxidative respiration for energy, and maintenance of cellular membrane integrity. Other essential processes include growth and differentiation, mitosis (cell division) in plant meristems, meiosis (sexual gamete production- pollen and seeds), uptake of ions and molecules, translocation of ions and compounds across cellular membranes, and transpiration. One or more of these essential processes must be disrupted in order for a herbicide to kill a plant (Ross and Childs 1996).

Foliar applied herbicides are either downwardly mobile, contact (non-translocated), or upwardly mobile in their mode-of–action. Downwardly mobile herbicides can be further divided into auxin growth regulators (2,4-D), aromatic amino acid synthesis inhibitors (glyphosate), branched chain amino acid inhibitors, chlorophyll/caratenoid pigment inhibitors, or lipid synthesis inhibitors (meristem membranes). Contact herbicides destroy by disrupting the cellular membranes of plants. Diquat belongs to this class of herbicides and functions by producing peroxides and free radicals in the cytoplasm upon exposure to light, which then destroy the lipid membranes of the cells almost immediately. Upwardly mobile herbicides move with the transpiration stream in the plant's xylem from the bottom to the top of the plant. This group of herbicides inhibits the photosynthetic pathways of metabolism. Soil applied herbicides inhibit cellular division in the roots, new shoots or both (Ross and Childs 1996).

Weedar ® 64, a dimethylamine salt formulation of 2,4-Dichlorophenoxyacetic acid (46.8% active ingredient) is an auxin growth regulator. This type of herbicide is applied to the foliage of plants, which almost immediately results in a bending and twisting of the leaves and stems. Delayed symptoms include root formation on dicot stems, mis-shapened leaves, stems, and flowers and abnormal roots. The amine salt form has been shown to be less toxic to fish than the ester forms of the herbicide, while invertebrates show a higher sensitivity to both the ester and amine forms of the compound than fish. The half-life of Weedar ® in aquatic environments can be short, from several days to several weeks (Extoxnet 2001). Rates of breakdown increase with increased levels of nutrients, sediments, and dissolved organic carbon. Maximum concentrations in surface waters are reached in one day, and then dissipate rapidly, especially in moving water (USDA 2002). Microorganisms readily breakdown 2,4-D along two separate metabolic pathways, metabolizing the compound into either pyruvate or 3-oxo-adipate. These intermediate metabolites serve as precursors in other metabolic pathways in the microorganisms (Hill *et al* 2000). The manufacturer's Material Safety Data Sheet (MSDS, Rhône-Poulenc) indicates that this product is for use in ponds, lakes, reservoirs, marshes, bayous, drainage ditches, canals, rivers, and streams that are quiescent or slow moving. It further stipulates that to avoid fish kills from the decaying plant material consuming oxygen, buffer strips of at least 100 feet wide should be left, and that treatment of these strips should be delayed for 4 to 5 weeks or until the dead vegetation has decomposed. This will be the primary compound used for water hyacinth control by the DBW, accounting for more than 97% of chemical usage. Concentrations of 2,4-D in the receiving waters shall not exceed 20 μg/L following application as directed by the NPDES permit for the WHCP.

Rodeo®, an isopropylamine salt formulation of glyphosate (53.8% active ingredients) is a non-selective, slow acting systemic herbicide that inhibits aromatic amino acid synthesis. This type of herbicide is sprayed on the foliage due to its rapid degradation by microbes. Symptoms include yellowing of new growth and death of treated plants in days to weeks (Ross and Childs 1996). Glyphosate inhibits an essential enzyme pathway, the shikimic acid pathway. This inhibition prevents plants from synthesizing three key aromatic amino acids, phenylalanine, tyrosine, and tryptophan. These enzymes are essential for the normal growth and survival of most plants. The key enzyme inhibited in this pathway is called EPSP synthase, to which glyphosate binds very tightly, rendering it unavailable to the pathway substrates. Plants are inefficient at metabolizing glyphosate, therefore the compound readily disseminates throughout the target plant and provides a more effective herbicide (Hartzler 2001). Animals do not synthesize either phenylalanine or tryptophan, and require them in their diets to survive. Glyphosate rapidly degrades in aquatic systems either by photodegradation (≈ 28 days) or by microbial degradation into sarcosine or formaldehyde, which then enters the intermediate single carbon metabolism of the bacteria. Glyphosate is also strongly adsorbed to soil particles and suspended particulate matter in the water column, rendering it biologically unavailable. Toxicological data indicates that the parent compound, glyphosate, is relatively benign to fish at expected acute field concentrations. Increased toxicity has been shown to occur when the parent compound is mixed with spray adjuvants and the inert portions of the manufacturer's formulation. The manufacture's MSDS (Monsanto) states that the product may be applied to emergent weeds in all bodies of fresh and brackish water which may include flowing, nonflowing, and transient waters. Rodeo® does not effectively treat plants which are completely submerged or have the majority of their foliage under water. Restrictions also apply to the application of Rodeo® near potable water intakes. As with 2,4-D, hypoxic conditions may be formed in the water column due to excessive weed decay from previous treatments, thereby causing fish to suffocate from a lack of dissolved oxygen. It is recommended that treating the area in strips may avoid this problem. This will be the least used compound for water hyacinth control by the DBW, accounting for no more than 0.5% of chemical usage. Concentrations of glyphosate in the receiving waters shall not exceed 700 µg/L following application as directed by the NPDES permit for the WHCP.

Reward®, diquat dibromide (36.4% active ingredient) is a broad spectrum contact herbicide that destroys lipid membranes and disrupts photosynthetic organelles. Diquat is readily absorbed through the plant cuticle and passes into the cytosol of the plant. It then forms superoxide free radicals that are subsequently converted into hydrogen peroxides by the enzyme superoxide dismutase. The hydrogen peroxide and superoxide anion can attack polyunsaturated lipids present in the cellular membranes to produce lipid hydroperoxides which, in turn, can react with unsaturated lipids to form more lipid free radicals, thereby perpetuating the system (Klassen 1996). Diquat rapidly adsorbs to soil particles and suspended particles in water. It thus becomes relatively biologically unavailable. Diquat dibromide's half-life is less than 48 hours in the water column, and may be on the order of 160 days in sediments due to its low bioavailability. Microbial degradation or sunlight may play roles in the degradation of the compound. Plants can absorb diquat from the water and concentrate it in the plant's tissues. Thus, low concentrations are effective for controlling aquatic weeds. Diquat is considered slightly toxic to fish and aquatic invertebrates. It has been reported to be less toxic in hard waters. There is little or no bioconcentration of diquat in fish due to its limited absorption from the gastrointestinal tract (Extoxnet 1993,1996). One research paper indicated that yellow perch exhibited respiratory difficulties when herbicide concentrations were similar to those present during aquatic vegetation control programs (Bimber 1976). The manufacturer's MSDS for Reward® (Zeneca) indicates that the herbicide may be applied to aquatic weeds. In public waters, the herbicide may be applied to still, slow-moving, other quiescent bodies of water and that if warning signs are required by state law they must be posted within the restricted area (1600 feet downstream of the treatment site). Due to the likelihood of hypoxic or anoxic conditions resulting from the decay of dead plant material, the MSDS requires that only one third to one half of the water body be treated at any one time, especially if dense weeds are present, and to wait 24 hours between treatments. Diquat will account for approximately 3% of the total amount of herbicide used in any given spray season. Concentrations of diquat in the receiving waters shall not exceed 0.5µg/L following application as directed by the NPDES permit for the WHCP.

In addition to the herbicides described above, three different adjuvants will be used in the application program. They are: (1) Placement®, a deposition and retention agent that reduces evaporation and drift of chemicals while increasing coverage and adherence in the target area; (2) R-11® Spreader-Activator, a combined spreading-activating compound for increasing the efficiency of action for agricultural chemicals where quick wetting and uniform coverage are required; and (3) Agri-Dex® Nonionic improves pesticide application by modifying the wetting and deposition characteristics of the application solution.

Placement® is composed of amine salts of organic acids, aromatic acids, and aromatic and aliphatic petroleum distillates. Placement® is used as a surfactant with all three herbicides at a rate of one part surfactant to four parts herbicide mixed into the total aqueous volume. The manufacture's MSDS (Wilbur-Ellis) recommends that no more than one quart of the surfactant be applied per surface acre of water.

R-11® Spreader-Activator (Wilbur-Ellis) is composed of alkyl aryl polyethoxylates, compounded silicone and linear alcohol. It is used with all three herbicides at the rate of two quarts per 100 gallons of spray solution.

Agri-Dex® is a non-ionic blend of surfactants and spray oil (Helena). It is composed of a paraffin based petroleum oil and polyoxyethylate polyol fatty acid esters. Agri-Dex® will be used with all three herbicides at a rate of one to four pints per 100 gallons of spray solution, not to exceed 2.5% volume/volume concentration.

III. STATUS OF THE SPECIES/CRITICAL HABITAT

Sacramento River Winter-run Chinook Salmon ESU and Critical Habitat

Listing History Overview

The Sacramento River winter-run chinook salmon (*Oncorhynchus tshawytscha*) has been determined by the National Marine Fisheries Service (NMFS) to be a unique run of chinook salmon, endemic to the upper reaches of the mainstem Sacramento River. The State of California listed winter-run chinook salmon as endangered in 1989 under the California Endangered Species Act (CESA). NMFS followed suit and listed the winter-run chinook salmon as threatened (54 FR 10260) under emergency provisions of the Endangered Species Act (ESA) in August 1989 and the species was formally listed as threatened in November 1990 (55 FR 46515). On June 19, 1992, NMFS proposed that the winter-run chinook salmon be re-classified as an endangered species pursuant to the ESA (57 FR 27416). NMFS finalized its proposed rule and reclassified the winter-run as an endangered species under the ESA on January 4, 1994 (59 FR 440).

On June 16, 1993 (58 FR 33212), NMFS designated critical habitat for the winter-run chinook salmon. This area was delineated as the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta, including Kimball Island, Winter Island, and Browns Island; all waters from Chipps island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Straits; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge. In the areas westward from Chipps Island, including San Francisco Bay to the Golden Gate Bridge, north of the San Francisco-Oakland Bay Bridge, this designation includes the estuarine water column and essential foraging habitat and food resources utilized by Sacramento River winter-run chinook salmon as part of their juvenile outmigration or adult spawning migrations. Within the Sacramento River this includes the river water, river bottom (including gravel for spawning), and adjacent riparian zone used by fry and juveniles for rearing.

Delta Critical Habitat

Numerous factors have effects on the condition and function of critical habitat necessary for the conservation of listed salmonids, including the Sacramento River winter-run chinook. CALFED, through its Comprehensive Monitoring, Assessment, and Research Program (CMARP) (CALFED July 2000) has described numerous areas of concern for the restoration of habitat for chinook salmon and steelhead trout. Within the Delta, alterations in the hydrology of the river systems feeding into the estuary have led to reductions in the volume of water flowing through the system and the timing of peak flows that stimulate migratory behavior in both juvenile and adult fish. The water storage and conveyance systems that have been constructed on the major rivers and tributaries of the Central Valley have permanently altered the natural flow patterns that native fishes have evolved to cope with. The reduction in the peak flow leads to alterations in the cycling of nutrients and changes in the transport of sediment and organic matter within the estuary. Likewise, estuarine circulation patterns have been disrupted, leading to changes in the physio-chemical profiles of the estuary, such as those for temperature and dissolved oxygen. Changes in the physio-chemical parameters of the Delta's waters can lead to distinct alterations in the historical distribution of animal and plant communities, upon which the juvenile salmon depend on for their forage base and for protective cover. Alterations in the flow patterns have led to reductions in the amount of out flowing water at the western margins of the Delta. This situation has led to increasing salinity levels within the western margin of the Delta and has changed the position and extent of the productive mixing zone upon which numerous species depend during their critical larval stages. Water flow patterns have been greatly affected by the operations of the south Delta pumping facilities. The normal pattern of water circulation within the Delta has been altered from its historical pattern, to a modified regime, which now includes a strong cross delta flow to the south, where the pumps are located as well as the creation of "null zones" ; areas where flows are negligible to nonexistent and the water becomes stagnant (Dept. of Water Resources 2001). This alteration disrupts normal environmental cues caused by tides and river out flows. Changes in the flushing rate and increased residence times of Delta waters has enhanced the degradative effects of increased input of contaminants and pollutants to the water system. This contamination has strong correlations to the increase in human activity in the terrestrial regions of the Delta. Agricultural and industrial activities have been the predominant sources of these contaminants, but the increase in the region's human population has resulted in a substantial increase in the number of new housing developments and a spreading urbanization of the Delta's terrestrial component. This urbanization has the potential to change the character of the contaminant profile, making it more complex and dispersed in its sources.

The construction of levees and the resulting channelization of the intricate web of Delta waterways have degraded the complexity of the historical habitats found in the Delta. The conversion of shallow water habitats that were found along the margins of the Delta waterways into that of a rip rap lined levee has radically altered the habitat that juvenile salmonids in the Delta are exposed to. Shallow water habitats are considered essential foraging habitats for juvenile salmonids, often supporting complex and productive invertebrate assemblages. The substrate that is provided by the stone rip rap is unsuitable for the colonization of native estuarine invertebrate species. Likewise, the construction of levees for flood control has disconnected the rivers and Delta from their historical floodplains. Juvenile salmonids utilize flood plains for foraging and as a refuge from high flow velocities during flooding events. Dredging of the channels for navigation or irrigation diversion purposes can result in the formation of anoxic bottom waters, and increased saltwater intrusion into upstream areas.

Introductions of invasive species, both intentionally and unintentionally, have significantly impacted the survival potential of juvenile salmonids. Non-native predators such as striped bass, large mouth bass and other sunfish species, present an additional risk to the of survival of juvenile salmonids migrating through the Delta that was not historically present prior to their introduction. These introduced species are often better suited to the changes that have occurred in the Delta habitat than are the native salmonids. The presence of the Asian Clam (*Potamocorbula amurensis)* has led to alterations in the levels of phyto- and zooplankton found in water column samples taken in the Delta. This species of clam is able to efficiently filter out and feed upon significant numbers of these planktonic organisms, thus reducing the population of the potential forage base for juvenile salmonids. Likewise, introductions of invasive plant species such as the water hyacinth, and *Egeria densa* has diminished access of juvenile salmonids to critical habitat (P. Moyle, personal communication). *Egeria densa* forms thick "walls" along the margins of channels in the Delta. This growth prevents the juvenile salmonids from accessing their preferred shallow water habitat along the channel's edge. In addition, the thick cover of *Egeria* provides excellent habitat for ambush predators, such as sunfish and bass, which can then prey on juvenile salmonids swimming along their margins. Water hyacinth creates dense floating mats that can impede river flows and alter the aquatic environment beneath the mats. Dissolved oxygen levels (DO) beneath the mats often drop below sustainable levels for fish due to the increased amount of decaying vegetative matter produced from the overlying mat. Like *Egeria*, water hyacinth is often associated with the margins of the Delta waterways in its initial colonization, but can eventually cover the entire channel if conditions permit it. This level of infestation can produce barriers to salmonid migrations within the Delta.

Historic Habitat Alterations

There is only one unique population of winter-run chinook salmon, the Sacramento River winter-run, within California. Prior to construction of Shasta and Keswick dams in 1945 and 1950, respectively, winter-run chinook salmon were reported to spawn in the headwater reaches of the little Sacramento, McCloud and Lower Pit River systems. Flows of water from constant temperature springs emanating from the lava fields around Mount Shasta and Mount Lassen fed them, and provided cool, stable temperatures for successful egg incubation over the summer. Populations of winter-run chinook may have numbered over 200,000 fish (Moyle *et al* 1989; Rectenwald 1989; Yoshiyama *et al* 1998). Construction of Shasta Dam blocked access to all of the winter-run chinook salmon's historical spawning grounds by 1942. Preservation of a remnant winter-run population was achieved through manipulation of the dam's releases to maintain a cold water habitat below the dam as far as Tehama.

One other potential population of winter-run chinook salmon occurred in the Calaveras River (NMFS 1997). Several dozen to several hundred adults spawned in reaches of the Calaveras River below New Hogan Dam from the early 1970s through the mid 1980s, but were extirpated by 1985, partially due to low flows in the Calaveras River, drought and agricultural diversions.

Prior to the construction of Shasta Dam, numerous smaller dams and agricultural diversions entrained juvenile winter-run chinook and blocked passage of adults migrating upstream. Among the earliest were the agricultural diversions of the Central Canal and Irrigation Company (CCIC) which began diverting unscreened water in 1906. This irrigation system was subsequently purchased by the Glenn-Colusa Irrigation District in 1920 and enlarged. The diversion was finally screened in 1935, but was damaged in 1938 and left unrepaired until the 1970s (NMFS 1997). In 1917 the Anderson Cottonwood irrigation diversion (ACID) dam was constructed on the Sacramento River in Redding, California and operated as a seasonal diversion dam (April-August). The dam was constructed without fish ladders and thereby effectively prevented any upstream migration of adult salmon above the dam when it was in operation. In 1927 a rudimentary fish ladder was constructed that permitted a limited number of fish to ascend into the upper watershed, but still impeded the majority of adult spawners from migrating upstream.

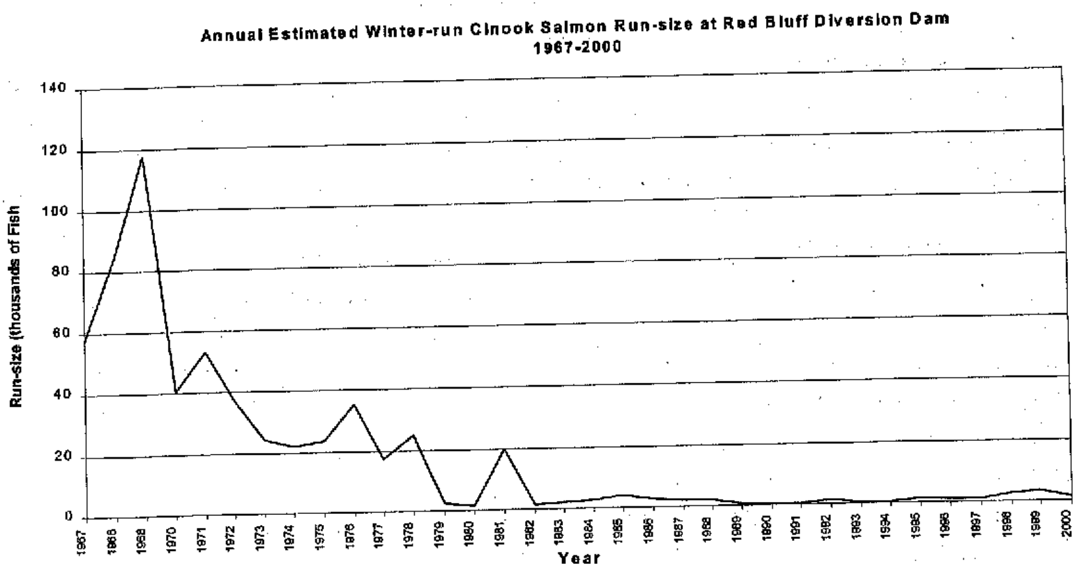
Consequently, this barrier substantially reduced population numbers. The Pit River watershed was also dammed during the 1920s with permanent structures, blocking at least 21 miles of spawning habitat, and perhaps as much as 71 miles depending on the upstream extent of adult migration. Shasta Dam construction was initiated in 1938 following the authorization of the Central Valley Project by Congress in 1937. In May of 1942, access to the upper Sacramento watershed was blocked to all salmonids, eliminating over 50 miles of spawning habitat that still remained above the dam. The operation of Shasta Dam significantly altered the functioning of the Sacramento River. Summer flows were higher and colder than historical flows while winter flows were warmer and lower than original flows. Reservoir levels significantly effected the temperature profile of releases from the dam. Low reservoir levels in dry years often resulted in increased river temperatures in the late summer as the reservoir was drawn down. This resulted in the losses of winter-run chinook eggs incubating in the gravel downstream of the dam when water temperatures exceeded 56° F. Keswick Dam operations often resulted in ramping rates that were incompatible to the requirements for winter-run chinook survival below the dam. Flow fluctuations in the spring disrupted spawning activities, or dewatered redds. In the fall, rapid ramping rates often stranded winter-run fry in side channels or broad gravel flats. The Red Bluff Diversion dam (RBDD), built in 1967, created another significant barrier to upstream passage for salmonids. Although equipped with fish ladders and bypass pipes, passage was still significantly impeded. This forced numerous salmon to either delay their upstream migration, or spawn downstream of the dam where water temperature was often too high to have successful incubation of the eggs. Fish that were delayed and made repeated attempts to pass the dam often had impaired spawning success due to the expenditure of energy reserves that could have been used for the production of viable eggs and upstream migration. RBDD also impinged on the success of juveniles emigrating downstream through entrainment into irrigation canals and the increased exposure to predation as they negotiated the dam (NMFS 1997).

Chemical contamination of the Sacramento River degraded water quality as early as the 1900s through agricultural discharges, mining pit effluents (acidic water, heavy metals), pesticide runoff, and fertilizer enrichment. In the delta, increased industrialization, urban development, and oil refining operations contributed pollutants to the ecosystem as early as 1890. Contamination of the ecosystem increased in proportion to the human population through the 1950s when water quality controls where first initiated. Thereafter, water quality began to improve as the controls took effect (NMFS 1997).

Environmental conditions have played a significant role in the decline of the winter-run chinook salmon population. During the severe droughts of the late 1920s and early 1930s, the population of winter-run chinook salmon on the Sacramento River declined precipitously. The effects of severe drought and the increased impairment of fish migration due to dam construction in the upper watershed combined to produce several years of reduced spawning success and adult escapement. This drought period was followed in the late 1930s by a cooler, wetter climatic period that was in part enhanced by the cold tailwater outflow from the recently completed Shasta Dam. Winter-run chinook salmon populations rebounded and continued increasing until the early 1970s, when a pattern of decline was again the dominant trend. Increased upstream water temperatures, agricultural diversions, and the initiation of operations of the RBDD all acted to reduce the success of salmon spawning and recruitment in the inland waters. Ocean conditions began to decline in the mid 1970s, and subsequently a strong El Niño condition developed in 1982-1983. Persistent dry weather conditions coupled with poor ocean conditions through most of the 1980s and early 1990s decreased the winter-run populations to their current depressed levels (NMFS 1997)(see Figure 1).

Figure 1:

Sources: NMFS 1997; PFMC, Review of 2000 Ocean Fisheries



Life History Considerations

The first winter-run chinook salmon migrants appear in the Sacramento-San Joaquin River during the early winter months (Skinner 1972). On the upper Sacramento River, the first upstream migrants appear during December (Vogel and Marine 1991) and peak during the month of March. The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Due to the lack of fish passage facilities at Keswick Dam, adults tend to migrate to and hold in deep pools between Red Bluff Diversion Dam (RBDD) and Keswick Dam before initiating spawning activities. Spawning occurs primarily from mid-April to mid-August with peak activity occurring in May and June in the river reach between Keswick and the RBDD (Vogel and Marine 1991).

The majority of winter-run chinook salmon spawners are three years old, although some two-year-old and four-year-old fish are also present. Winter-run chinook salmon prefer to migrate upstream in water temperatures between 57° and 67° F. Maximum water temperatures for holding fish are 59°– 60° F but the maturation of ovarian tissue is enhanced at water temperatures of 55° – 56° F (Boles *et al* 1988).

Chinook salmon spawning occurs predominately in swift, relatively shallow riffles or along the margins of deeper runs. Spawning occurs at depths ranging from 6 inches to as deep as 10-15 feet but the preferred depth is from 1-3 feet. Optimum spawning substrate is clean, loose gravel with less than 5% fines, ranging in diameter form 0.75 inches to 4.0 inches. Optimal current flow is 1.5 feet per second (fps) but can range from 0.33 to 6.2 fps (Healey 1991). Gravels which are subjected to high bed loads of fine sediments, or which are prone to aggregation with clay or fines are unsuitable for spawning substrate (NMFS 1997). In order to maintain a sufficient dissolved oxygen concentration in the intra-gravel spaces, a minimum level of intra-gravel water flow must be maintained. This depends on gravel size and porosity, as well as water flow rate, water depth, and water quality (Bjornn and Reiser 1991). Chinook eggs are the largest of the *Oncorhynchus* species and have the lowest surface to volume ratio, thus diffusion across the egg chorion membrane is limiting. In order to assure an adequate rate of diffusion across the chorion membrane, the intra-gravel percolation rate must be sufficient to maintain dissolved oxygen levels in the egg pocket and to carry away metabolic waste products. Chinook which are forced to spawn in areas of unsuitable gravel substrate or insufficient water flows will suffer increased egg mortality.

Chinook salmon fry emerge from the gravel, depending on water temperature, between 85 days (12° C) and 192 days (6° C) post fertilization. Winter-run chinook hatch in about 50% of the time required for emergence (40 d @ 12° C, 90 d @ 6° C), (Heming 1982). Maximum survival of incubating eggs and pre-emergent fry occur at water temperatures between 40° F and 56° F. Mortality of eggs and fry initiates at temperatures exceeding 57.5° F and reaches 100% mortality when water temperature exceeds 62° F (Boles *et al* 1988). Other sources of mortality for incubating eggs are dewatering of the redds, superimposition of other redds, physical damage from floods or predators, and toxicants in the water source.

Post-hatch fry remain in the interstitial spaces of the redd's gravel while absorbing their yolk sacs. This period can be as long as the incubation period. The fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), generally at night. After emergence, fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris. Fry may remain in the general area of their emergence or they may disperse downstream. Water flows may affect the timing of downstream migration, with higher flows enhancing earlier outmigrations of the fry (Ford and Brown 2001). Soon after emergence, fry finish absorbing their yolk sacs and begin feeding on small terrestrial and aquatic insects and small aquatic crustaceans. When the juvenile salmon reach a length of 50 to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energetic expenditures. Territorial, agonistic behavior of dominant juveniles will often force subordinate fish into less favorable water conditions or encourage downstream migration into less populated river stretches. Emigration for winter-run chinook past the RBDD may occur as early as late July or August, but generally peaks in September and can extend into the next spring in dry years (Vogel and Marine 1991). In the mainstems of larger rivers, juveniles tend to migrate along the margins of the river, rather than in the increased velocity found in the thalweg of the channel. When the channel of the river is greater than 9 to 10 feet in depth, the juvenile salmon inhabit the surface waters (Healy and Jordan 1982).

Juvenile winter-run salmon begin to show up in the Sacramento-San Joaquin Delta from October to early May based on data collected from trawls, beach seines, and salvage records at the State and Federal water projects (DFG 1993). The peak of juvenile arrivals is from January to March. These new migrants tend to rear in the upper delta areas for about the first two months (Kjelson *et al* 1981, 1982). Maturing chinook fry and fingerlings prefer to rear where ambient salinity is up to 1.5 to 2.5 $^0/_{00}$ (Healy 1980, 1982; Levings *et al* 1986). Juvenile chinook salmon will forage in shallow intertidal and subtidal areas such as mudflats, marshes, channels and sloughs. Such habitats provide a productive foraging area, as well as structure for protective cover (McDonald 1960; Dunford 1975). Juvenile chinook salmon follow the tidal cycle in their movements within the estuarine habitat, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1981; Levings 1982; Healey 1991). As juvenile chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tide into shallow water habitats to feed (Allen and Hassler 1986). Kjelson *et al* (1982) reported that juvenile chinook also demonstrated a diurnal migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column.

Juvenile chinook salmon feed on small invertebrates of aquatic and terrestial origins while in the Delta. Cladocerans, copepods, amphipods and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al* 1982; Sommer *et al* 2001). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al* 2001). Optimal water temperatures for the growth of juvenile chinook salmon in the Sacramento-San Joaquin Delta are 54° – 57° F (Brett 1952). In Suisun and San Pablo Bays water temperatures reach 54° F by February in a typical year. Other portions of the Delta do not reach this temperature until later in the year, often not until after spring runoff has occurred.

Fry remain in the estuarine habitat until they reach a fork length of about 118 mm. For winter-run chinook salmon this may take 5 to 10 months residence time in freshwater. Emigration from the delta may begin as early as November and continue through May (Fisher 1994; Myers *et al* 1998).

Winter-run chinook salmon are particularly susceptible to extinction due to the limitations of access to suitable spawning grounds and the reduction of their genetic pool to one population (NMFS 1997). The winter-run also has lower fecundity rates than other races of chinook salmon in the Central Valley (Fisher 1994), averaging 1000 to 2000 eggs less per female than the other runs (3,700 winter-run, 5,800 late fall, 4,900 spring-run, and 5,500 fall-run).

Central Valley Spring-run Chinook Salmon ESU and Critical Habitat

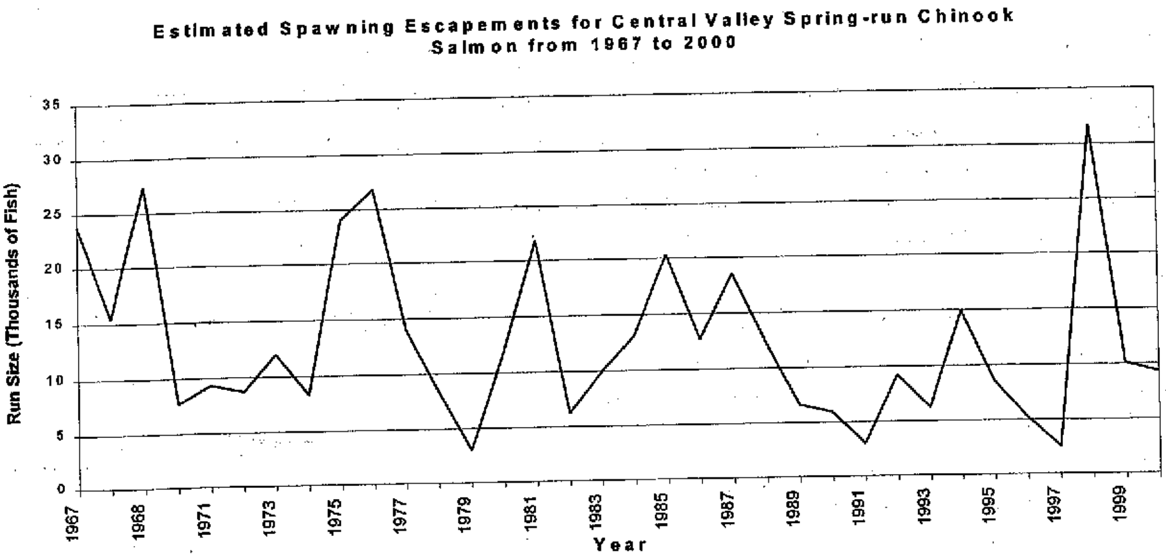
The Central Valley spring-run chinook salmon (*Oncorhynchus tshawytscha*) was classified as a distinct evolutionary significant unit (ESU), endemic to the Central Valley of California by genetic data reported in 1999 (Banks *et al.*, 1999). The State of California listed the spring-run chinook salmon as a threatened species under CESA in February of 1999, followed by a federal listing by NMFS on September 16, 1999 as a threatened species (50 FR 50394). On February 16, 2000, NMFS designated critical habitat for the Central Valley spring-run chinook (65 FR 7778). Critical habitat was defined as all river reaches accessible to listed chinook salmon in the Sacramento River and its tributaries in California. Also included in the designation are river reaches and estuarine areas of the Sacramento-San Joaquin Delta, all waters from Chipps island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay and the Carquinez Straits, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay north of the San Francisco/Oakland Bay Bridge from San Pablo Bay to the Golden Gate. Many of the same factors described above that have led to the decline in the winter-run ESU are also applicable to the spring-run ESU, particularly the exclusion from historical spawning grounds found at higher elevations in the watersheds.

Historically, spring-run chinook salmon were abundant throughout the Sacramento and San Joaquin River systems. They constituted the dominant run of salmon in the San Joaquin River system prior to being extirpated by the construction of dams on the main tributaries. Spring-run salmon typically spawned in higher elevation streams approximately 1500 feet above sea level in elevation or up to ~2500 feet to 3000 feet above sea level if spawning occurred earlier in such watersheds as the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit Rivers. Spring-run chinook salmon preferred higher elevation streams with adequate spring fed run-off or snowmelt run-off to keep summer water temperatures low. Spring-run chinook salmon would hold in the cold water streams for several months prior to spawning, conserving energy expenditures while their gonadal tissue matured. Spring-run chinook salmon tended to be smaller bodied than the other runs of chinook in the Central Valley, enabling them to ascend higher into the tributaries. Currently, spring-run chinook salmon cannot access most of their historical spawning and rearing grounds in the Central Valley due to the construction of impassable dams in the lower portions of the Valley's waterways. Today, only remnant populations of naturally self-sustaining spring-run chinook occur in the Central Valley. The only streams that are considered to harbor naturally spawning wild stocks of spring-run chinook are Mill, Deer and Butte creeks. All of these creeks are east-side creeks that are currently undammed. Some additional spawning occurs in the mainstem tributaries of the Sacramento River. However, the genetic characteristics of these fish suggest introgression with both spring-run and fall-run hatchery fish. The limited spawning habitat available to this run of fish exposes it to serious threats from activities that lead to degradation of its habitat. Elevated water temperatures, agricultural and municipal water diversions, regulated water flows; entrainment into unscreened or poorly functioning screened diversions and habitat degradation all negatively impact the spring-run chinook ESU.

Adult Central Valley spring-run chinook salmon migrate into the Sacramento River system between March and July, peaking in May through June. They spawn from late August through early October, peaking in September (Fisher 1994; Yoshiyama *et al* 1998). Between 56 to 87% of adult spring-run chinook salmon that enter the Sacramento River basin to spawn are three year olds (Calkins *et al* 1940; Fisher 1994). Spring-run fry emerge from the gravel of their redds from November to March and spend about 3 to 15 months in freshwater habitats prior to emigrating to the ocean (Kjelson *et al* 1981). Downstream emigration by juveniles occurs from November to April. Upon reaching the Delta, juvenile spring-run chinook salmon forage on the same variety of organisms while utilizing the same type of habitats as previously described for the winter-run juveniles.

Adult escapement/spawning stock estimates for the past thirty years have shown a highly variable population for the spring-run chinook ESU. Even though the abundance of fish may increase from one year to the next, the overall average population is generally declining during this time period (see Figure 2).

Figure 2:
Source: PFMC 2000 Ocean Fisheries, Yoshiyama 1998.



Central Valley Steelhead ESU and Central Valley Steelhead Critical Habitat

The Central Valley steelhead (*Oncorhynchus mykiss*) was determined by NMFS to be an ESU endemic to the Central Valley of California. On August 9, 1996 NMFS proposed to list the Central Valley steelhead as endangered (61 FR 41541). On March 19, 1998, the Central Valley steelhead was listed as threatened (63 FR 13347), and its critical habitat designated on February 16, 2000 (65 FR 7764).

Critical habitat for the Central Valley steelhead was designated to include all river reaches accessible to listed steelhead in the Sacramento and San Joaquin Rivers and their tributaries in California. Also included in this determination are river reaches and estuarine areas of the

Sacramento-San Joaquin Delta, all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, grizzly Bay, Suisun Bay and the Carquinez Straits, all waters of San Pablo bay westward of the Carquinez bridge, and all waters of San Francisco Bay north of the San Francisco/Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge. Excluded from this determination are the areas of the San Joaquin River upstream from the confluence with the Merced River, and those areas upstream of impassable dams on the tributaries or above longstanding, naturally impassable barriers, such as natural waterfalls that have been in existence for at least several hundred years. The same factors that have negative effects on the winter-run chinook salmon also impinge upon the Central Valley steelhead population. Anthropogenic alterations to the ecosystem have had the most impact to steelhead stocks.

Historically, Central Valley steelhead once were found throughout the Sacramento and San Joaquin drainages, where waterways were accessible to migrating fish. Steelhead were also once present in the upper San Joaquin River basin, above the current Friant Dam location. Steelhead commonly migrated far up tributaries and into headwater streams where cool, well oxygenated water is present year-round. Currently, within the Central Valley, viable populations of naturally produced steelhead are found only in the Sacramento River and its tributaries (USFWS 1998). Wild steelhead populations appear to be restricted to tributaries on the Sacramento River below Keswick Dam, such as Antelope, Deer and Mill creeks and in the Yuba River, below Englebright Dam (McEwan and Jackson 1996). At this time, no significant populations of steelhead remain in the San Joaquin River basin (USFWS 1998), however, small persistent runs still occur on the Stanislaus and perhaps the Tuolumne Rivers. Steelhead are found in the Mokelumne River and Cosumnes River, but may be of hatchery origin. It is possible that other naturally spawning populations exist in other Central Valley streams, but are not detected due to a lack of sufficient monitoring and genetic sampling of rainbow/steelhead resident fish (IEP Steelhead Project Work Team 1999).

Central Valley Steelhead are all considered to be winter-run steelhead (McEwan and Jackson 1996), which are fish that mature in the ocean before entering freshwater on their spawning migrations. Prior to the large scale construction of dams in the 1940s, summer steelhead may have been present in the Sacramento River system (IEP Steelhead Project Work Team 1999). The timing of river entry is often correlated with an increase in river flow, such as occurs with freshets and the associated lowering of ambient water temperatures. The preferred water temperatures for migrating adult steelhead are between 46° and 52° F. Entry into the river system can range from July through May, with a peak in late September. Spawning can start as early as December, but typically peaks between January and March, and can continue as late as April, depending on water conditions (McEwan and Jackson 1996). Steelhead are capable of spawning more than once as compared to other salmonids which die after spawning. However the percentage of repeat spawning is often low, and is predominately only female fish (Busby *et al* 1996). Steelhead prefer to spawn in cool, clear streams with suitable gravel size, water depth, and water velocities. Ephemeral streams may be used for spawning if suitable conditions in the headwaters remain during the dry season and are accessible to juvenile fish seeking thermal refuge from excessive temperatures and dewatering in the lower elevation reaches of the natal stream (Everest 1973; Barnhart 1986).

During spawning, females select gravel that ranges in size from 0.2 to 4.0 inches in diameter (Bjornn and Reiser 1991). Steelhead prefer to use gravel sized material but will utilize mixtures of sand-gravel and cobble-gravel. The substrate should be highly permeable to keep the incubating eggs well oxygenated and should contain less than 5% sand and silt. The preferred water depth for spawning is approximately 14 inches but can range from 6 to 24 inches (Bovee 1978). Current velocities for spawning activities range from 1 to 3.6 ft/sec, but preferred velocities are about 2 ft/s (McEwan and Jackson 1996). The ideal temperature range for spawning is from 39° to 52° F. Egg incubation is affected by temperature and the optimum range for egg development is from 48° to 52° F with egg mortality beginning to occur at 56° F. Hatching of steelhead occurs in about 31 days at 51° F (Leitritz and Lewis 1980) and the yolk sac fry will remain in the gravel for another four to six weeks before emerging. This is dependent on redd depth, gravel dimensions, level of siltation, and water temperature (Shapovalov and Taft 1954). For Central Valley waters, this is usually between February and May, but can be as late as June. After emerging from the gravel, fry migrate to shallow, protected areas associated with the margins of the natal stream (Barnhart 1986). Fry will take up and defend feeding stations in the stream as they mature, and force smaller, less dominant fry to lower quality locations (Shapovalov and Taft 1954). In-stream cover and velocity refugia are essential for the survival of steelhead fry, as is riparian vegetation, which provides overhead cover, shade, and complex habitats. As fry mature, they move into deeper waters in the stream channel, occupying riffles during their first year in fresh water. Larger fish may inhabit pools or deeper runs (Barnhart 1986). Juvenile steelhead feed on a variety of aquatic and terrestrial invertebrates and may even prey on the fry and juveniles of steelhead, salmon, and other fish species. Steelhead juveniles may take up residence in freshwater habitat for extended periods of time prior to emigrating to the ocean. Optimal water temperatures for fry and juveniles rearing in freshwater is between 45° and 60° F. The upper lethal limit for steelhead is approximately 75° F (Bjornn and Reiser, 1991); temperatures over 70° F result in respiratory distress for steelhead due to low dissolved oxygen levels.

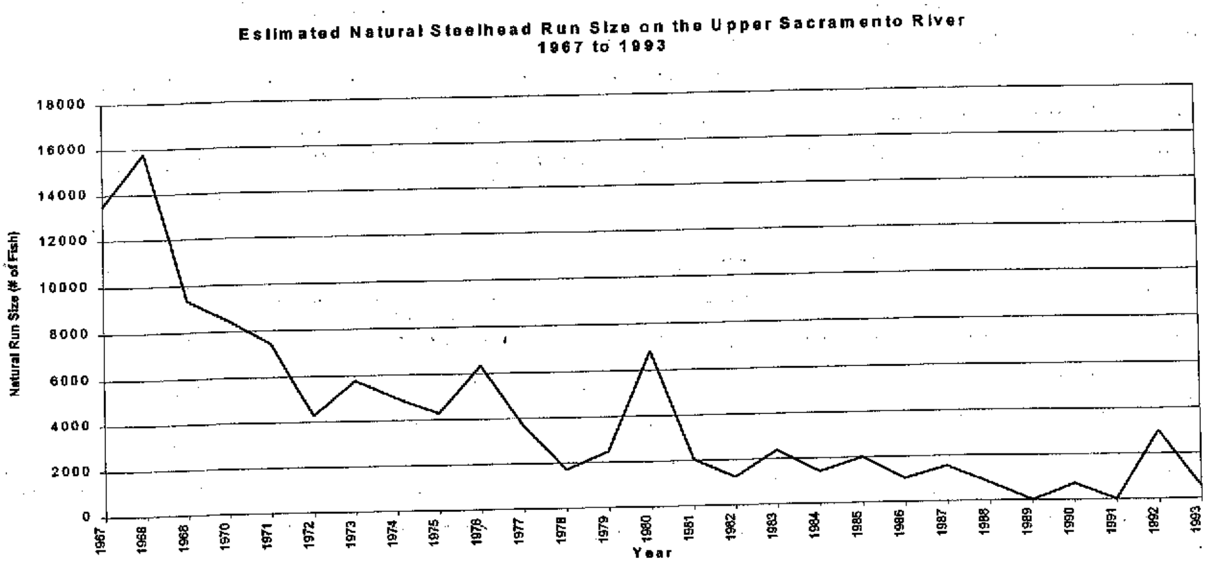
Steelhead will typically spend one to three years in freshwater before migrating downstream to the ocean. Most Central Valley steelhead will migrate to the ocean after spending two years in freshwater, with the bulk of migrations occurring from November to May, but some low levels may occur during all months of the year. The out-migration peaks from April to May on the Stanislaus River whereas the American River has larger smolt-sized fish emigrating from December to February and smaller sized steelhead fry coming through later in the spring (March and April). Feather River steelhead smolts are observed in the river until September, which is believed to be the end of the outmigration period (CMARP 2000). In preparation for their entry into saline waters, juvenile steelhead, like winter and spring-run chinook juveniles, also undergo a process called smoltification. During this process, fish undergo physiological and morphological changes, which allow the fish to adapt to the hypertonic environment found in the ocean. These changes involve alterations in enzyme levels, increasing activity of special salt excretion cells in the fish's gill epithelium and changes in renal activity to handle the concentrated urine production necessary to cope with the stress of osmoregulation in the ocean environment (Moyle and Cech 1982). The smolts can range in size from 14 to 21 cm in length (Barnhart 1986). Steelhead can spend variable amounts of time in the ocean prior to returning on their spawning migrations, ranging from one year to as many as four. Central Valley steelhead typically spend only one to two years in the ocean prior to returning to spawn in the rivers of the Central Valley. Over the past 30 years, steelhead populations have declined substantially as illustrated in Figure 3 for the upper Sacramento River natural run size.

Figure 3:
Source: McEwan and Jackson 1996

IV. ENVIRONMENTAL BASELINE

Sacramento-San Joaquin Delta

The Sacramento- San Joaquin River drainage system comprises streams and rivers draining primarily from the Sierra Nevada Range into the two major rivers of the Central Valley, the Sacramento River (fed by its major tributaries, the American, Yuba, and Feather Rivers) flowing southward and the San Joaquin River (fed by the Merced, Tuolumne, and Stanislaus rivers) flowing northward. The Sacramento-San Joaquin drainage basins encompass about 40% of the state of California (approximately 153,000 km^2) and carry about 600 m^3 /s of water (mean annual flow). The two rivers join in a complex series of channels and islands called the Sacramento-San Joaquin Delta (Delta). Two main east-side tributaries flow into the Delta, the Calaveras and the Mokelumne/ Cosumnes River groups. The Delta flows westward into Suisun Bay and eventually into the northern reaches of San Pablo Bay through the Carquinez Straits (Conomos *et al* 1985;



Nichols *et al* 1986; and Wright and Philips 1988).

The San Francisco Bay estuary, with a surface area of 1,240 km^2, is the largest coastal embayment on the west coast of the United States. Salt water tidal influence extends over 100 km landward from the Bay's entrance at the Golden Gate, influencing river height as far inland as Sacramento and Tracy in the Central Valley. The extent of salt water intrusion into the Delta (2x zone- 2 $^0/_{00}$ practical salinity units) extends into the eastern regions of San Pablo Bay and the Carquinez Straits during a normal winter, but extends to the eastern reaches of Suisun Bay during summer. Currently the Bay's tidal prism is approximately 24% of its total volume (Conomos *et al* 1985) and is of a mixed semi-diurnal type, thus there are two unequal high tides every 25 hours, which enhances the mixing and movement of water bodies in the Delta. This relatively large tidal prism, compared to other estuaries, enables the delta to exchange a greater amount of water volume per tidal cycle than is commonly experienced in most estuarine habitats.

The depth and shape of San Francisco Bay and the Delta have been radically altered since the mid-1800s. Conomos *et al* (1985), Nichols *et al* (1986), and Wright and Philips (1988) summarized these changes to the Bay-Delta system. Hydraulic mining practiced from 1854 to 1884 to uncover gold ore in the Sierra Nevada mobilized tens of millions of cubic meters of rock, soil, and debris. This inflow of debris laden runoff choked rivers and tributaries, smothering salmon spawning grounds, filling in river channels, and creating periodic extensive flooding. Downstream, in the Delta and Bay, 1.0, 0.75, and 0.25 m of sediment was deposited in Suisun, San Pablo, and San Francisco Bays respectively as a result of the hydraulic mining era. Accelerated rates of natural sedimentation processes contributed to a permanent reduction in the open water areas of the bay through shoaling and expansion of marshlands across newly formed mudflats. This alteration in the natural landscape of the Bay and Delta altered the native biological communities, smothering benthic habitats with siltation, decreasing deep-water habitat and increasing shallow water and marsh habitat which were colonized by both native and invasive species. Conversely, reductions in the area of native marshlands also occurred in both the Delta and Bay. Nearly 1,400 km^2 of freshwater marsh in the Delta and 800 km^2 of saltwater marsh in the Bay were diked and drained to create farmland in the Delta or salt evaporation ponds in the Bay. Later, industrialization and urbanization reclaimed even more wetland acreage until today only 125 km^2 (about 6%) of the original 2,200 km^2 area of native wetlands remains. The original wetlands served as significant foraging areas for numerous species, enhanced nutrient cycling and retention as well as acting as natural filters to enhance ambient water quality.

Delta Water Quality

The water quality of the Delta has been negatively impacted over the last 150 years. Increased water temperatures, decreased dissolved oxygen levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. The Central Valley Regional Water Quality Control Board in its 1998 303(d) list characterized the Delta as an impaired waterbody having elevated levels of chlorpyrifos, DDT, diazinon, electrical conductivity, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan and toxaphene), mercury, low dissolved oxygen, organic enrichment, and unknown toxicities (CRWQCB-CVR 1998).

Reduction in water flows, removal of riparian corridors and their shading function, and increased levels of industrial and agricultural discharges have increased ambient water temperatures in the Delta. Water temperatures typically exceed 60° to 66° F (15.5° C to 18.3° C) from April through September. Salmonids are physiologically suited to inhabit coldwater temperature regimes, and increased water temperatures will lead to physiological stress in salmonids. An increase in water temperature causes a concurrent decrease in the amount of oxygen that can be dissolved in the water. Reduced oxygen content in the water will result in the fish having to expend more energy to circulate a greater volume of water through its gills to extract the minimal amount of oxygen needed for survival. A fish can either increase its ventilation rate, ventilation volume or both in response to hypoxic conditions. In general, as water temperature increases, the oxygen consumption rate of the fish will also increase, indicating an increased metabolic load on the fish's body. Metabolic energy that might have been used for other physiological functions must now be used to maintain respiratory requirements, to the detriment of those other functions (Moyle and Cech 1982). At 57° F, pure water will have a dissolved oxygen concentration of approximately 10 mg/L. At 65° F, the concentration of dissolved oxygen will have been reduced to approximately 9 mg/L. These levels will be significantly lower for waters in the Delta due to the presence of dissolved minerals, organic matter, and other compounds that reduce the solubility of oxygen or consume oxygen due to chemical reactions.

Dissolved oxygen concentrations are often further decreased due to the discharge of municipal, industrial and agricultural effluents that contain compounds that increase the biological oxygen demands (BOD) of the receiving waters. Salmonid physiology requires oxygen concentrations of at least 7.75 mg/L to function at optimum levels. Dissolved oxygen levels of 6.0 mg/L or less result in salmonids exhibiting signs of physiological distress (Reiser and Bjornn 1979).

Increased trace metal burdens such as mercury, copper, and selenium are currently found in water quality samples from the Delta, and often are above criteria levels designed to protect the beneficial uses of water in the Delta. Increased levels of heavy metals are detrimental to the health of an organism because they interfere with metabolic functions by inhibiting key enzyme activity in metabolic pathways, decrease neurological function, degrade cardiovascular output, and act as mutagens, teratogens or carcinogens in exposed organisms (Rand 1995; Klassen 1996).

Likewise, elevated levels of pesticides and other contaminants are found in water quality samples. Pesticides typically alter the neurological functioning of exposed organism by interfering with synaptic junction physiology within the central nervous system and neuro-muscular junctions. This interference leads to degraded locomoter activity, loss of sensory input, and disrupted equilibrium. Organisms that suffer these degradations may exhibit behavioral changes that lessen the ability to reproduce, forage, or avoid predators. In general, water degradation or contamination can either lead to acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically when concentrations are lower, to chronic or sublethal effects that reduce the fitness of the organism to survive over an extended period of time. Mortality may become a secondary effect due to compromised physiology or behavioral changes that lessen the organism's ability to carry out its normal activities. For listed species this may be effects directly upon the listed fish or upon its prey base, which reduces the forage base available to the listed species.

Sediment Quality

Sediments can either act as a sink or as a source of contamination depending on hydrological conditions and the type of habitat the sediment occurs in. Sediment provides habitat for many aquatic organisms and is a major repository for many of the more persistent chemicals that are introduced into the surface waters. In the aquatic environment, most anthropogenic chemicals and waste materials including toxic organic and inorganic chemicals eventually accumulate in sediment (Ingersoll *in* Rand 1995). Contaminated sediments can either be directly toxic to aquatic organisms or a source of contaminants for bioaccumulation in the food chain (US EPA 1994). Throughout the Delta and San Francisco Bay systems, sediments have been contaminated with industrial and urban runoff, which have carried compounds that are resistant to biological or natural chemical degradation. These contaminants are often localized around industrial and urban outfalls, storm drains, and agricultural drains. Metals such as silver, copper, cadmium, and mercury are regionally important components of the sediment contamination. Likewise selenium, a naturally occurring mineral in the marine shales of the western Central Valley, is an important contaminant in the San Joaquin River drainage due to its elevated levels in agricultural drain return waters. Selenium contamination of waters in the Central Valley has been linked to birth defects, decreased fertility and tumors in animals at the Kesterson National Wildlife Refuge and in other receiving waters in the nation (Lemley 1996, 1999).

Throughout the Central Valley, elevated levels of both organo-chlorine and organo-phosphate pesticides from agricultural practices have contaminated the river basin's sediments. These compounds are frequently elevated during rain run-off events when the contaminated terrestrial soils are transported overland into the Delta waters. Pesticides are generally organ system specific in that they primarily target the nervous system. However, reports indicate that the newer pyrethroid insecticides may have endocrine disruptor activity, as well as an extreme toxicity to fish and other gill breathing organisms (Bradbury and Coats 1989; Haya 1989).

In addition, runoff from both agricultural returns and urban sources provide significant sources of nutrients to the aquatic system in the form of phosphates and nitrogen containing compounds that lead to the eutrophication of the receiving waters. Eutrophication is characterized by an increase in phytoplankton biomass (algal bloom). The increase in the biomass of phytoplankton has been implicated as one of the main sources of the low dissolved oxygen problem in the Stockton Deep Water Channel.

Finally, the Delta has elevated levels of other persistent organic compounds such as polychlorinated biphenyls (PCB's), dioxins, and polycyclic aromatic hydrocarbons (PAH's), that can adsorb to sediments or organic materials, but are bioavailable to the food chain. Many of these contaminants can be bio-magnified in the food chain, leading to an eventual decrease in organismal populations through declines in reproductive success, formation of lesions in organs, or declines in metabolic status or immune response when the threshold sensitivity of the target organism is exceeded.

Exposure to contaminated sediments may directly cause deleterious effects to listed salmonids if the individual fish is directly exposed to it. This may occur if the fish swims through a plume of the resuspended sediments or rests on contaminated substrate and absorbs the toxic compounds through one of several routes: dermal contact, ingestion, or uptake across the gill epithelia. Elevated contaminant levels may be found in localized "hot spots" where discharge occurs or where river currents deposit sediment loads. Sediment contaminant levels can thus be significantly higher than the overlying water column concentrations (EPA 1994). However, the more likely route of exposure to salmonids is through the food chain, where the fish feed on organisms that are contaminated with the toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself where exposure to pore waters occurs. Therefore the degree of exposure to the salmonids depends on their trophic level and the amount of contaminated forage base they consume. Salmonids exposed to increased levels of contaminants can be expected to have a decreased ability to forage or escape predators, lower fertility and reproductive abilities, increased susceptibility to disease, and an increased probability of developing lesions or tumors (Rand 1995).

Water Operations

The Sacramento River Basin provides approximately 80% of the water flowing into the Delta, the San Joaquin River provides an additional 15% and the eastside tributaries provide the remaining 5%. This historically amounted to almost 34 km^3 of freshwater annually before 1850. The highly seasonal inflow is composed of rainfall runoff in the winter and snowmelt runoff during early summer. With the completion of the state and federal reservoir projects on all of the major tributaries in the watersheds of the Sacramento and San Joaquin Rivers, water inflow has become artificially managed for human needs. The major rivers have been dammed for flood control, water storage, and hydroelectric power, while additional water is withdrawn for local irrigation and for export to central and southern California for agricultural, industrial and domestic uses. Currently, less than 40% of historical flows reach San Francisco Bay through the Delta.

The alterations of flow have led to changes in the natural environment and hydrological processes in the river basins and Delta. Insufficient flows in winter and spring and the channelization of rivers and streams have prevented the natural cleansing, recruitment and movement of substrate in these waterways. This reduces the availability of suitable spawning gravel to listed salmonids. In addition, dammed tributaries are frequently starved for suitable sized gravels as the dams block downstream movement of substrate from upstream reaches. Furthermore, dam operations have altered the normal water flow patterns on these tributaries. Higher flows occur in summer due to dam releases for agricultural and domestic uses, while lower flows occur during winter and spring when the reservoirs are filling. This alteration in the normal flow pattern has necessitated unique patterns of water operations at the dams to facilitate fish migration and rearing.

Operations of the Central Valley Project/ State Water Project (CVP/SWP) in the south Delta have significantly altered water flow patterns in the Delta. All juvenile salmon and steelhead eventually migrate downstream from the upper river spawning and rearing habitats to the lower river reaches and the Delta prior to entering the ocean as smolts. Historically, these waters were very productive to juvenile salmonids. Over the last 150 years, the Delta has been modified extensively for human purposes, which has led to an overall degradation in the quality of habitat for salmonids. As migrating salmonids enter the complex waterways of the Delta in its current configuration, they are subjected to numerous conditions that potentially could have significant negative effects or even result in mortality to the migrating fish. The operations of the water export facilities have substantially altered normal flow patterns in the Delta. When exports are high, water is drawn into the southern portions of the Delta through the Delta Cross Channel, Georgiana Slough and Three Mile Slough from the mainstem of the Sacramento River. Likewise, water flow in the lower San Joaquin River can even be reversed and drawn towards the pumping facilities through the interconnected waterways of the South Delta. Fish are drawn with these altered flow patterns towards the pumping facility. These alterations in water flow have resulted in fish from both the Sacramento River and the San Joaquin River systems being drawn into the South Delta as a result of the water diversions. Lower survival rates are expected due to the longer migration routes, where fish are exposed to increased predation, higher water temperatures, unscreened water diversions, poor water quality, reduced availability of food resources, and entrainment into the CVP/SWP export facilities near Clifton Forecourt in the South Delta (USFWS 1990, 1992). Attempts have been made to change operational` procedures in the management of the CVP/SWP pumping schedules and the Delta Cross Channel to minimize loss of migrating salmonids. Currently, the CVP/SWP pumping facilities are operated to avoid pumping large exports of water during critical migratory or life stage phases of listed fish. Real time monitoring of fish movements, and the development of more efficient fish screens have led to a decrease in the numbers of fish lost to the projects, but entrainment still accounts for significant losses to the listed fish populations.

Restoration and Environmental Enhancement Programs

CALFED

On December 15, 1994, the State of California, the Federal government, water users and environmental interests entered into a three year agreement to ensure water quality and supply and to protect the quality of San Francisco Bay and the Sacramento/San Joaquin Delta habitats with the signing of the Bay-Delta Accord. In May of 1995, the CALFED Bay Delta Program was established to carry out the goals of the accord. CALFED has a three phased implementation plan that will stretch over at least three decades. Projects will be divided into four main areas: ecosystem quality; water supply; water quality and vulnerability of delta functions. Currently an "operations" group (CALFED Ops Group) coordinates CVP/SWP projects operations, using current biological and hydrological information for the management of water quality, endangered species, and the Central Valley Project Improvement Act. Water quality objectives and criteria established by the Accord are based on historical operations of the CVP/SWP and the life history needs of the fish species affected by Delta water operations. The combined effect of these various criteria has improved the environmental baseline of the Delta, affording a level of protection for listed species and critical habitat conservation. The goals of CALFED's Ecological Restoration Program are "to improve aquatic and terrestrial habitats and natural processes to support stable, self-sustainable populations of diverse and valuable plant and animal species, and includes recovery of species listed under State and Federal Endangered Species Acts" (CALFED 2000). Examples of projects conducted under the auspices of CALFED include large scale restoration projects on Clear Creek, Deer Creek, and the San Joaquin River, removal of a select group of dams, purchase of additional upstream flows, protection and restoration of the natural meander corridor to the Sacramento River, and improvement of water quality throughout the watershed.

USGS Monitoring Programs

USGS has developed a biological monitoring procedure that has been in continuous use in the Bay-Delta since 1977. In 1990, the USGS began a special series of investigations to describe the origins and effects of toxic contaminants in San Francisco Bay. Early results have shown that pesticides applied in the Central Valley of California are carried by rivers into the Bay at levels exceeding national guidelines (USGS 2001). Biological tests have shown river waters to contain high levels of pesticides soon after they are applied to fields.

Anadromous Fish Restoration Plan

USFWS' Anadromous Fish Restoration Plan (AFRP) has identified the direct and indirect impacts of the CVP and SWP Delta pumping operations as a significant factor limiting natural production of anadromous fish in the Central Valley. The AFRP has developed numerous actions in the Delta designed to improve the outmigration and survival of juvenile salmon in the Delta (e.g. Delta Cross Channel closures, export curtailments, positive Q (discharge) west conditions (USFWS 1997).

CVPIA Section 3406(b)(1) directs the Secretary of Interior to develop and implement a program that makes all reasonable efforts to ensure by the year 2002, natural production of anadromous fish in California's Central Valley streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967-1991. Fully implemented, the AFRP will meet the mitigation, protection, restoration, and enhancement purposes established by the CVPIA. The six anadromous fish species identified for restoration efforts under the AFRP are chinook salmon, steelhead, striped bass, American shad, white sturgeon, and green sturgeon. Since 1995, the AFRP has assisted in the interim implementation of over 70 projects to restore natural production of anadromous fish, under the leadership of the Bureau of Reclamation (USBR) and the U.S. Fish and Wildlife Service (USFWS).

AFRP actions include non-flow fish management projects such as physical facilities to improve fish passage (e.g. fish screens and ladders), channel restoration to improve habitat of rearing and spawning, replenishment of spawning gravels and fish screening to prevent the entrainment of juvenile fish and associated fish passage facilities for adults. Non-flow AFRP actions include channel and habitat restoration projects, and upstream adult fish passage facilities not associated with fish screens. In addition to improving fish passage, dam removal and modification will also benefit listed salmonids and designated critical habitat by improving downstream flow conditions, water quality (e.g. temperature), sediment transport, and other hydrological processes.

Striped Bass Habitat Conservation Plan

The California Department of Fish and Game has an ESA section 7 permit to annually stock San Francisco Bay with striped bass (*Morone saxatilis*), an introduced exotic species that is a popular game fish. California Department of Fish and Game (DFG) has been releasing approximately 1.275 million striped bass yearlings into San Francisco Bay as part of a five-year Striped Bass Conservation Plan developed with NMFS , and the USFWS, to prevent further striped bass declines and stabilize the striped bass population at 1994 levels of 712,000 adults. Striped bass is a predator that may be impeding the recovery of listed species including steelhead trout and chinook salmon. The Striped Bass Conservation Plan focuses on striped bass recovery and maintenance, and is part of DFG's commitment to: 1) stabilize and restore the Estuary's striped bass fishery; 2) restore and improve habitat for striped bass and other aquatic species; 3) ensure that striped bass recovery programs do not jeopardize the continued existence of any state or federally listed species. The Conservation Plan also supports the Fish and Game Commission's goals to stabilize and restore the striped bass fishery in the Sacramento-San Joaquin Estuary. Planting of striped bass into the Delta has been suspended as of 2001, triggered by the 712,000 adult population level.

National Invasive Species Management Plan

The National Invasive Species Management Plan was created by Executive Order 13112 on February 3, 1999. The Executive Order (EO) directs Federal agencies to use their authorities to prevent the introduction of invasive species, to control, monitor and to restore native species. The EO established a Federal Interagency Invasive Species Council (Council), co-chaired by the Secretaries of the Interior, Agriculture, and Commerce and includes State, Treasury, Defense, Transportation and the Environmental Protection Agency. The Council is directed to create an invasive species management plan. The Secretary of the Interior established an advisory committee to provide information and advice for consideration by the Council including recommended plans and actions at the local, state, regional and ecosystem-based levels to achieve the goals of the Management Plan. The Council acts in cooperation with states, tribes, scientific, agricultural organizations, conservation groups and other stakeholders. The Management Plan is updated every two years with an accompanying public report on success in implementation. The first edition of the Management Plan reviewed relevant existing programs and authorities, recommended needed measures, and identified legislative needs.

National Invasive Species Act of 1996

This act reauthorizes and amends the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (P.L. 101-646), which focused on preventive measures for the introduction and spread of aquatic nuisance species in marine and fresh waters of the U.S. The National Invasive Species Act of 1996 extends to the control of ballast water from ships, which has been a major contributor to introduced invasive species in domestic waters.

The Western Regional Panel on Aquatic Nuisance Species (WRP) was formed in 1997 to help limit the introduction, spread and impacts of aquatic nuisance species into the Western Region of North America. The purposes of the WRP are to: (1) identify Western Region priorities for responding to aquatic nuisance species; (2) make recommendations to the Task Force regarding an education, monitoring (including inspection), prevention, and control program to prevent the spread of the zebra mussel west of the 100th Meridian; (3) coordinate, where possible, other aquatic nuisance species program activities in the West not conducted pursuant to the Act; (4) develop an emergency response strategy for Federal, State, and local entities for stemming new invasions of aquatic nuisance species in the region; (5) provide advice to public and private individuals and entities concerning methods of preventing and controlling aquatic nuisance species infestations; and (6) submit an annual report to the Aquatic Nuisance Species Task Force describing activities within the western region related to aquatic nuisance species prevention, research and control. The Aquatic Nuisance Species Task Force (ANSTF), co-chaired by the USFWS and National Oceanic and Atmospheric Administration (NOAA), coordinates governmental efforts related to nonindigenous aquatic species in the United States with those of the private sector and other North American interests. CALFED is represented on the ANSTF, and it has formulated the CALFED ERP Nonnative Invasive Species Strategic and Implementation Plan (July 2000) with it's number one objective being to "develop and identify the leadership, authority and organization necessary to predict, prevent and reduce the impacts of 'nonnative invasive species' (NIS) introductions in the ecosystems of the San Francisco Bay-Delta, the Sacramento and San Joaquin Rivers, and their watersheds." A draft CALFED Rapid Response Plan, currently in review, streamlines a response process to an NIS by an identified lead agency and resources. Once adopted, the response plan could be utilized to contain and eradicate identified NIS, including Water hyacinth and *Egeria* in California.

Total Maximum Daily Load Programs

The State Water Resources Control Board (SWRCB), in conjunction with nine semi-autonomous regional boards, regulates water quality in the state of California. The regional boards implement water quality programs in accordance with policies, plans, and standards developed by the state board. One of their responsibilities is to develop Total Maximum Daily Load (TMDL) programs, allocating responsibility for reducing non-point source pollution in the state's most seriously impaired water bodies. TMDLs are developed for each pollutant contributing to the impairment of a listed water body. Only three of the 18 impaired water bodies on the state's initial list from 1976 have been de-listed. The most recent list of impaired water bodies in the state (1998) lists 509 impaired water bodies throughout the state, for which 1,471 TMDLs have to be developed. The California Department of Water Resources Legislative Analyst's Office suggests that the SWRCB develop a 10-year development plan, through 2010-2011, for the TMDL program. Timing will coincide with U.S. Environmental Protection Agency (EPA) guidance that all TMDLs from the 1998 list of impaired water bodies be complete by 2011. The plan will include: (1) a workload summary; (2) funding requirements; (3) evaluation development; (4) a monitoring plan; (5) a schedule for achieving water quality milestones and objectives; and (6) recommendations for improvements to the plan (DWR 2001).

IEP Projects in the Delta

There are 22 Interagency Ecological Program (IEP) projects currently starting or on-going in the Delta. The IEP is a collaborative effort among nine Federal and California State agencies. The objective of the IEP is to obtain the appropriate physical and biological information necessary for protection and management of the Sacramento-San Joaquin Estuary. The information gathered by the IEP program is used to adjust operations of Reclamation's CVP. These projects explore predator-prey relationships; fish abundance and size distribution; geographic distribution, population studies; impacts from water operations; nursery values; entrainment monitoring; and fish screen criteria development. In 2001, a total of 122 Interagency Ecological Program (IEP) habitat- and/or fish-related projects, based in the Delta, were funded through CALFED. Project proposals covered the spectrum from watershed restorations, feasibility studies, toxicity/invasive species studies, sediment/water quality studies, and geomorphoric/hydrologic studies, to migration studies, prey reserves, habitat expansion, education programs, fish monitoring, and fish tag evaluations. These projects serve not only to improve environmental conditions in the Delta, but also expand the knowledge base of the Delta's ecosystem.

Egeria densa Control Program

The purpose of the *Egeria densa* Control Program (EDCP) is to control the growth and spread of *Egeria* in Delta waterways. Three state-registered control methods are proposed for EDCP treatment sites: 1) contact herbicide Reward® (active ingredient Diquat); 2) systemic herbicide Sonar® (active ingredient Fluridone) in liquid A.S., granular SRP, and precision-release pellet SR forms; and 3) mechanical harvesting. Reward® would be applied in fast moving waters (76% of treatment acreage); Sonar® would be applied in slow-moving, quiescent waters (21% of treatment acreage), and mechanical harvesting would be used to gain immediate control of 3% of the treatment acreage. Based on the proposed 5-year treatment period, the DBW would apply 10,600 gallons of Reward®, 300 gallons of Sonar®A.S., and 13,500 pounds of Sonar® SRP to Delta waters annually. Sonar® PR, recently incorporated in the control regime, may be applied at some time during the 5-year EDCP. The EDCP would treat 1,583 acres in years 1-2, increasing treatment to 1,733 acres in years 3-5. All proposed treatment sites occur in the Delta; there is currently no evidence of *Egeria* found within Suisun Marsh. Specific details of the EDCP can be found in the *Egeria densa Control Program Volume 1 (Draft Environmental Impact Report).*

EDCP Project Area

Thirty-five (35) sites have been prioritized as potential EDCP treatment sites within the Delta. The Delta is defined as being bordered to the north by the I Street Bridge in Sacramento, to the west by the Suisun Marsh Salinity Control Gates near Pittsburgh, to the south by the junction of Highways 5 and 205, and to the east by the Port of Stockton, covering overlapping jurisdiction of six counties. The sites chosen for the EDCP are scattered throughout the Delta, but are prioritized on the basis of channel navigation.

Komeen® Research Trials

Komeen® is a non-selective liquid contact herbicide that contains eight-percent elemental copper. The herbicide acts by inhibiting photosynthesis after being absorbed into plant tissue. DBW has determined that Komeen® would be more effective in controlling *Egeria* in high flow conditions in comparison to other EDCP herbicide controls. The goals of the Komeen® Research Trials are to determine the long-term fate of copper applied to Delta waters, and whether copper compounds in Komeen could ionize to more toxic forms of copper. There will also be additional laboratory toxicity tests conducted to assess Komeen toxicity to some fish and invertebrate species. The proposed research trials would involve Komeen® application at three 50-acre sites in the Delta twice each year for two years, resulting in treatment of 300 acres per year, or 600 treatment acres over the two-year period. Applications would be made to achieve a water column concentration of 0.75 ppm copper, for a total amount of 6,075 gallons per year, or 12,150 gallons of Komeen® over the two-year trial period. Komeen® would be applied using weighted hoses dragged below the water surface. Approximately 6,075 gallons of Komeen® would be applied to the Delta annually. The three primary components of the Two-Year Komeen® Research Trials are: (1) monitoring of sediment copper concentration, (2) assessment of Komeen® /copper bioaccumulation in target and non-target organisms, and (3) laboratory toxicity studies. It is currently unknown if Komeen applications produces measurable increases in downstream sediment copper load or whether the copper compound in Komeen® could ionize to more toxic forms of copper. If at the end of the 2-year study, it is concluded by the USDA-ARS that Komeen® use is consistent with EDCP objectives and does not result in significant environmental impacts, the DBW would take steps to incorporate Komeen® into the EDCP. USDA-ARS would be required to re-initiate ESA consultation for project analysis incorporating Komeen® as an herbicide in controlling *Egeria.*

Komeen® Project Area

Three sites have been proposed for implementation of the Komeen trials during the 2-year study. The first two sites, Sherman Island and Big Break Island, are high flow sites with partial and large tidal exchanges, respectively; the third trial site, Disappointment Slough, is an area with high water flow and large tidal exchange (DBW 2000).

Salmonid Presence in the Delta

Chinook salmon and steelhead are present in the Delta throughout the year as juveniles migrate out to sea, or adults return to natal streams or sites of hatchery release. The start and duration of emigration is dependent upon water year type, precipitation, accretion in the Sacramento River, and water flows. Distinct emigration pulses coincide with high precipitation, increased turbidity, and storm events (CMARP 2000).

Juvenile winter-run chinook emigrate from the Delta to the ocean from mid-December or January through June. Peak emigration of Sacramento River winter-run chinook salmon through the Delta generally occurs from January through April, but the range may extend from September up to June (Schaffter 1980, USFWS 1992,1998). Adult Sacramento River winter-run chinook salmon leave the ocean and migrate through the Sacramento-San Joaquin Delta to the upper Sacramento River from December through June. (Hallock *et al* 1961).

Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento Basin migrated downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall. Steelhead smolts show up at the Tracy and Banks pumping plants between December and June. Adult steelhead migrate upstream in the Sacramento River mainstem from July through March, with peaks in September and February (Hallock *et al* 1961).

The timing of upstream migration is generally correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures.

Spring-run chinook fry and fingerlings can enter the Delta as early as January and as late as June; a cohort's length of residency within the Delta is unknown but probably lessens as the season progresses into the late spring months (DFG 1998). Spring-run chinook salmon adults are estimated to leave the ocean and enter the Sacramento River from March to July (Myers *èt al* 1998). This run timing is well adapted for gaining access to the upper reaches of river systems, 1,500 to 3,000 feet in elevation, and prior to the onset of high water temperatures and low flows that would inhibit access to these areas during the summer and fall.

Peak occurrence of juvenile salmonids in the Delta varies annually. Standardized sampling during spring for a Delta monitoring program in the 1970s with a beach seine produced peak occurrence in December and March for late-fall, winter, and fall/spring runs (Burmester and Brandes 2000). Peaks shifted from November, March, and April using a Kodiak trawl, to December, March, and May with a Chipps Island midwater trawl. Peak occurrence of fall run in the lower San Joaquin River beach seine and Mossdale Kodiak trawl was in February and May, respectively (Burmester and Brandes 2000). Shifts in juvenile salmonid abundance demonstrated with various sampling gear reflect discretionary use of the Delta by juvenile salmonids based on their size, age, and degree of smoltification.

Integration and Synthesis of the Environmental Baseline

The decline of Pacific salmonids in the Delta region is not dependent upon a single factor, but rather is an interplay of several variables interacting with each other to affect the status of the species populations and the habitat necessary for their survival. Identifying any one factor does not exclude the possibility that others are also acting, perhaps synergistically, to prolong or enhance the decline, or conversely, in an antagonistic fashion to slow or perhaps even reverse the declining population trend. Furthermore, the factors affecting the current trends in the salmonid populations appear to include both natural and anthropogenic influences:

- Dam construction on the mainstem Sacramento River and the main tributaries to the Sacramento and San Joaquin rivers have significantly altered the historical seasonal flow patterns in the Delta. Salmonid populations within the Central Valley of California are evolutionarily adapted to these historical flow patterns and the water quality characteristics associated with them.

- Operation of federal and state water programs have significantly reduced the volume of water flowing to and through the Delta. Currently less than 40% of historical flows reach San Francisco Bay through the Delta.

- Reduction in the flow of water to the Delta has resulted in declining water quality within the Delta. The Delta is currently listed as having impaired water quality, and the SWRCB has implemented TMDLs for this waterbody. Numerous anthropogenic factors, including industrial, agricultural, and urban sources of pollutants have exacerbated the effects of low water flows to the Delta.

- Wetlands within the Delta region have been reduced to 6% of their historical distribution. This loss of wetlands has resulted in the elimination of crucial shallow water habitat which provided shelter and foraging opportunities for juvenile salmonids, as well as the positive effects to water quality that the natural filtering capacity of wetlands provided.

- Currently, programs such as CALFED and AFRP are instituting positive changes to water operations and habitat management that will benefit numerous aquatic and terrestrial species, including listed salmonid species. These changes should enhance the quality of the habitat in the Delta, which may facilitate populations of listed salmonids to stabilize or even increase as a result of the changes.

V. EFFECTS OF THE ACTION

Effects of Herbicidal Application on Salmonids

The application of herbicides to waters of the Delta under the USDA-ARS and DBW Water Hyacinth Control Program in 2002 may potentially affect Sacramento River winter-run and Central Valley spring-run chinook salmon and the Central Valley steelhead in both direct and indirect ways.

Dissolved Oxygen Levels

Juvenile salmonids may be directly affected through the reduction in DO levels resulting from the decomposition of treated plants. Low DO levels (< 3 mg/L) can result in fish kills if fish are unable to move out of the zone of hypoxic or anoxic waters. Low dissolved oxygen levels are particularly harmful to salmonids, which have a high metabolic requirement for dissolved oxygen (Bjornn and Reiser 1991). Studies have shown that dissolved oxygen levels below 5 mg/L have a significant negative effect on growth, food conversion efficiency, and swimming performance. High water temperatures, which result in reduced oxygen solubility, can compound the stress on fish caused by marginal DO concentrations (Bjornn and Reiser 1991). Reductions in the fitness of the juvenile salmonid as a result of low DO can make the individual fish more susceptible to predation, disease, and failure to undergo smoltification due to insufficient energy reserves. Adult salmonids may experience delayed migration through Delta waters if DO is below concentrations needed for survival. Delay in upstream migration can have a negative impact on the maturation of gonadal tissue, particularly if ambient water temperatures in the Delta are also elevated. Salmonids exposed to elevated temperatures during gonadal maturation have reduced fertility and lower numbers of viable eggs (CMARP 2000). Previous studies have shown that levels of dissolved oxygen (DO) under water hyacinth mats can be hypoxic or even anoxic (Bailey and Litterick 1993; Toft 2000) having values that are less than 5 mg/L. Fish exposed to extended dissolved oxygen levels below 5 mg/L are usually compromised in their growth and survival (Piper *et al* 1982). NMFS expects that fish and mobile invertebrates will generally avoid areas with large mats of water hyacinth due to the decreased ambient levels of dissolved oxygen in the water column. The applications of herbicides are expected to initially decrease dissolved oxygen levels even further in areas treated for the plant. This results from the decomposition of the dead vegetable matter and an increase in biological oxygen demand. This effect is expected to be transitory as the decaying vegetation is dispersed by tidal and river currents from the treatment area. Areas of higher tidal and river current exposure will be flushed faster than areas of low water body exchange, such as dead end sloughs and restricted peripheral channels. Additional parameters affecting the DO levels are the rate of decay for the treated vegetation which is dependent on ambient water temperature and microbial activity. Higher water temperatures should theoretically result in higher microbial activity, thus resulting in a faster decline in the DO levels. However, the duration of the depressed DO levels should be shorter than in a cooler temperature profile due to the vegetative biomass being metabolized at a faster rate. Conversely, a cooler ambient temperature would result in a prolonged DO depression, although perhaps not to the hypoxic levels reached in a warmer water profile.

Narcosis

Fish, which are exposed to elevated concentrations of polar and nonpolar organic compounds, such as the herbicides used in the WHCP, can become narcotized. Narcosis is a generalized nonselective toxicity that is the result of a general disruption of cell membrane function. The process of narcosis is poorly understood, but is thought to involve either a "critical volume" change in cellular membranes due to the toxicant dissolving into the lipid membrane and altering its function, or by the "protein binding" process in which hydrophobic portions of receptor proteins in the lipid membrane are bound by the toxicant molecules, thus changing the receptor protein's function (Rand 1995). Exposure to elevated concentrations of the herbicides would occur in the very upper most portions of the water column, directly beneath the fringe of the water hyacinth mat. A fish with narcosis would be susceptible to predation as a result of a loss of equilibrium, a reduction in swimming ability or a lack of predator avoidance behavior. Furthermore, a fish with narcosis would also have difficulty maintaining its position in the water column, and could potentially be carried by water currents into areas of sub-optimal water quality where conditions may be lethal to salmonids (hypoxic regions underneath water hyacinth mats).

Sublethal Effects on Salmonids

In contrast to the acute lethality endpoints utilized by the WHCP, nonlethal or sublethal endpoints are more appropriate to the levels of exposure likely to be seen in the herbicide application protocol employed in the program. Sublethal or nonlethal endpoints don't require that mortality be absent; rather it indicates that death is not the primary toxic endpoint being examined. Rand (1995) states that the most common sublethal endpoints in aquatic organisms are behavioral (e.g., swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological (e.g., growth, reproduction, and development), biochemical (e.g., blood enzyme and ion levels), and histological changes. Some sublethal effects may indirectly result in mortality. Changes in certain behaviors, such as swimming or olfactory responses, may diminish the ability of the salmonids to find food or escape from predators and may ultimately result in death. Some sublethal effects may have little or no long-term consequences to the fish because they are rapidly reversible or diminish and cease with time. Individual fish may exhibit different responses to the same concentration of toxicant. The individual condition of the fish can significantly influence the outcome of the toxicant exposure. Fish with greater energy stores will be better able to survive a temporary decline in foraging ability, or have sufficient metabolic stores to swim to areas with better environmental conditions. Fish that are already stressed are more susceptible to the deleterious effects of contaminants, and may succumb to toxicant levels that are considered sublethal to a healthy fish.

Indirect Effects

Indirect effects may result from temporary reductions in primary productivity and invertebrate populations in treated reaches, increased water temperatures in previously shaded habitats, and exposure to predation resulting from a loss of cover as a result of exposure to the chemical compounds used in the WHCP. Invertebrate populations may be reduced either by direct toxic exposure to herbicides in the water column or indirectly by drifting decaying vegetation smothering the benthic substrate they inhabit. Either avenue would diminish the forage base needed by juvenile salmonids utilizing the Delta as a rearing habitat. Juvenile salmonids would then be forced to enlarge their forage area to successfully ingest the necessary caloric intake for survival. The rate of survival for juvenile salmonids would be a balance between the amount of metabolic energy expended in swimming during foraging behavior versus the amount of caloric intake achieved from the prey captured during foraging. Caloric intake needs to exceed the metabolic cost of swimming in order for the juvenile fish to have sufficient energy reserves for growth and other metabolic needs. An additional indirect effect is the increase in monitoring for the status of listed fish (i.e. delta smelt and split tail), where listed fish other than the target species are caught as bycatch in the sampling procedures. This bycatch often results in the loss of the listed salmonids. Finally, operation of the program's watercraft in the project area may result in direct and indirect effects due to wake turbulence, sediment resuspension, physical impact with propellers, and discharge of pollutants from the motor's exhaust and lubrication systems.

Beneficial Effects

Reductions in the percentage of water hyacinth infested waterways will theoretically result in better flows through these waterways, re-establishment of native aquatic vegetation, and recolonization of habitats with native invertebrate species. These changes should result in positive effects on the suitability of the Delta waterways for salmonid rearing and migration. Although these benefits are stated in the DBW Biological Assessment, definitive data was not given to support this claim and hence must be taken as potential benefits rather than actual benefits.

Potential Extent of Exposure

The proposed spraying season for the 2002 WHCP is the six and one half months from April through mid-October in the action area (Delta plus San Joaquin River areas). This treatment period would overlap one month of adult winter-run migration through the Delta (22%) and 2 months of the juvenile winter-run chinook emigration (29%); a majority of the spring-run adult migration (66%) and some juvenile spring-run emigration (16%), 2 months (33%) of the juvenile steelhead migration through the Delta and 100% of the adult steelhead emigration. During juvenile out-migration, the winter-run are sub-yearling stage (age zero); spring-run are at the yearling stage (age 1) and steelhead smolts are post yearlings (age 1.5 – 2).

Toxicity of WHCP Herbicides

Water hyacinth is a floating macrophyte, thus the herbicides are applied by spraying the foliage of the plant above the surface of the water. A conservative estimate of the amount of herbicide entering the water column under normal conditions is approximately 10-20% of the sprayed volume (Anderson 1982).

Weedar®

Under the WHCP, Weedar® will be applied at the rate of 2 to 4 quarts/ acre (or 4 pounds equivalent per acre) with an instantaneous concentration of 1,200 and 9,600 ppm from the sprayer unit nozzle (actual concentration of active ingredient is 46.8 % therefore 560 ppm to 4,800 ppm). Instantaneous field concentrations for the herbicide were calculated by DBW to be 1.50 mg/L to 3.10 mg/L in 1 acre-foot of water, and 150 µg/L to 310 µg/L per 10 acre-feet of water if all of the herbicide were to enter the water and complete mixing were to occur. However, actual field concentrations are likely to be much different. Less than 10 to 20% of the herbicide enters the water column from the overlying water hyacinth mat, but mixing is neither instantaneous nor homogenous. In addition, complete mixing will only occur after an appreciable time lag, and herbicide concentrations may be substantially higher in the microzone near the surface of the water directly beneath the treated vegetation.

The typical Weedar® concentrations found in the field are expected to be much less than the expected acute toxicity levels (LC_{50}) for 96-hour exposure studies. The 96 hour LC_{50} for 2, 4-D for rainbow trout (*O. mykiss*) ranges from ~100 mg/L (Johnson and Finley 1980) to more than 1000 mg/L (Doe *et al* 1988). The formulation of 2,4-D has been shown to affect toxicity, with the acid and amine forms considerably less toxic to different species of salmonids than the ester formulations (Meehan *et al* 1974). The levels of toxicity of 2,4-D have been shown to be affected by ambient environmental pH, with the toxicity of the compound decreasing with increasing pH. This is due to the degree of dissociation of the acidic herbicide (Doe *et al* 1988). Water hardness has also been implicated as a factor in affecting 2,4-D toxicity to salmonids. Hard water was shown to reduce the toxicity of the 2,4-D to different species of salmonids (Wan *et al* 1991). Invertebrates have been shown to have differing sensitivities to 2,4-D (George *et al* 1982; Sarkar 1991; and Abdelghani *et al* 1997) and are frequently more sensitive to 2,4-D than fish.

Physiological and morphological alterations have been seen in fish exposed to 2,4-D. Common changes seen in physiological parameters are changes in enzyme activity levels (Nešković et al., 1994). Exposure to 2,4-D has also been shown to cause morphological changes in gill epithelium in carp. These changes include lifting of the gill epithelium and clubbing of gill filaments, but are considered non-lethal if the fish is removed to clean water for recovery (Nešković *et al* 1994). In field conditions this would be equivalent to swimming to an untreated area or the herbicide concentration falling off to negligible levels. Carpenter and Eaton (1983) investigated the metabolism of 2,4-D in rainbow trout after injection, and found that almost 99% of the compound is excreted in the urine as unchanged 2,4-D, with a half-life of only 2.4 hours. Less than 1% was found in the bile of treated fish, presumably as a conjugated metabolite. Similar results were shown for metabolic studies in channel catfish (*Ictaluris punctatus*) where 2,4-D was administered orally (Plakas *et al* 1992). The responses described in the references above all occurred at considerably higher exposure concentrations than are expected to be seen in the WHCP applications in the Delta.

Assuming a worst case situation, using the highest predicted environmental concentration (3.1 mg/L) and the lowest LC_{50} for salmonids (100 mg/L), the ambient environmental concentration of 2,4-D at the time of application is still approximately 32 times lower than the 96 hour LC_{50} for salmonids. Furthermore, the concentration of 2,4-D is expected to decrease rapidly through dilution and mixing by local water movement. Weedar® is also readily degraded in aquatic systems; its decomposition enhanced with increased levels of nutrients, sediment loads, and dissolved organic carbon levels. Under field conditions, Weedar® is expected to have a half-life of several days to several weeks (Extoxnet 2001). The environmental fate characteristics of 2,4-D and the application rates used in the WHCP would indicate that the concentration levels of the herbicide achieved in Delta waters should be significantly below the acute toxicity levels of listed salmonids.

However, sublethal effects are of concern. As mentioned previously, these are the category of effects that are most likely to occur during this program. Sublethal effects are characterized as those that occur at concentrations that are below those that lead directly to death. Sublethal effects produce less obvious effects on behavior, biochemical and/or physiological functions and the histology of the fish. In addition, potential narcosis in exposed fish can lead to negative effects including increased predation and death as described above. Degradation of critical habitat is expected to occur due to decreases in dissolved oxygen, decreases in the invertebrate standing population which reduces the forage base available to the juvenile salmonids and changes in water quality, particularly ambient water temperature due to a decrease in vegetated cover.

Rodeo®

Under the WHCP, Rodeo® will be applied at the rate of 0.75 to 1.0 gallon of herbicide per 100 gallons of water with an instantaneous concentration of 7,200 and 9,600 ppm from the sprayer unit nozzle (actual concentration of active ingredient is 53.8 % therefore 3,900 ppm to 5,200 ppm). Instantaneous field concentrations for the herbicide were calculated by DBW to be 2.3 mg/L to 3.10 mg/L in 1 acre-foot of water, and 230 µg/L to 310 µg/L per 10 acre-feet of water if all of the herbicide were to enter the water and complete mixing were to occur. However, actual field concentrations are likely to be much less as only 10 to 20% of the herbicide enter the water column. Furthermore, complete mixing will only occur after an appreciable time lag, and herbicide concentrations may be substantially higher in the microzone near the surface of the water.

Typical field concentrations of Rodeo® are expected to be less than the acute 96 hour LC_{50} for glyphosate, the active ingredient of the herbicide Rodeo®. However the acute toxicity levels for the formulated mixture found in Rodeo® is higher than the glyphosate alone. This has been attributed to the addition of surfactants to the mixture. The 96 hour LC_{50} for Rodeo®, calculated as the glyphosate acid for rainbow trout and chinook salmon ranges from 130 mg/L to 140 mg/l in soft water to 210 mg/L to 290 mg/L in hard water for rainbow trout and chinook salmon respectively (Mitchell *et al* 1987). Wan *et al* (1989) also found a correlation between water hardness and toxicity for five species of salmonids (coho, chum, chinook, and pink salmons and rainbow trout). In soft water, chinook salmon and rainbow trout had similar sensitivities to the herbicide, 19 mg/L to 10 mg/L respectively as glyphosate, and 33 mg/L as Roundup®. However in hard water, the LC_{50} for glyphosate was 197 mg/L and 211 mg/L for rainbow trout and chinook salmon respectively, considerably less toxic than in soft water. Conversely, the Roundup® formulation was more toxic in hard water, 14 mg/l and 17 mg/L for trout and salmon respectively. Folmar *et al* (1979) found the 96 hour LC_{50} for several different invertebrate and fish species, including rainbow trout. Acute toxicities to rainbow trout were 8.3 mg/L for Roundup® and 140 mg/L for technical glyphosate. The toxicity for the surfactant alone was similar to that of Roundup®, 2.0 mg/L versus 8.3 mg/L for Roundup®.

Folmar *et al* (1979) also investigated the effects of glyphosate on the reproductive success and behavior of rainbow trout. No significant effects were detected between the control fish and those exposed to the glyphosate in either their gonadal somatic index or fecundity when exposed to 2 mg/L of glyphosate for 12 hours followed by a 30 day recovery period in freshwater. The data found in Folmar *et al* (1979) indicates that eggs of rainbow trout are less sensitive to the toxicity of Roundup® than other life stages. Toxicity increased at the yolk-sac stage and early swim up stages, but decreased in the fingerling stage, as fish grew larger. The values for the 96 hour LC_{50} exposures are as follows: eyed eggs – 16 mg/L; sac-fry –3.4 mg/L; swim-up fry – 2.4 mg/L; fingerling (1.0 g) - 1.3 mg/L; and fingerling (2.0 g) – 8.3 mg/L. Rainbow trout also did not avoid concentrations of the isopropylamine salt of glyphosate up to 10 mg/L (Folmar 1976; Folmar *et al* 1979). Morgan *et al* (1991) found similar reactions of rainbow trout fry exposed to Vision®, a glyphosate formulation with either 10% or 15% surfactant. The nominal concentration that elicited a threshold avoidance reaction from the test fish were 54 ppm for Vision-15 and 150 ppm for Vision-10, roughly two times the LC50 for the fish. Threshold effects for alterations in the fish's behavior where observed at 13.5 ppm for Vision-15, and 37.5 ppm for Vision-10 following 24 hours of exposure. These changes were characterized by erratic, gyrating swimming at 24 hours, with the fish eventually becoming moribund at 48 hours.

Physiological studies conducted by Mitchell *et al* (1987) on coho salmon showed no adverse effects of exposure of up to 2.3 mg/L of Roundup® in the seawater adaptation of the fish. There were no significant differences in the biochemical and morphological parameters measured in this study between control and treated fish (hematocrit, condition factor, length or weight, or ionoregulatory gill enzymes). Similar findings were made by Janz *et al* (1991) using the glyphosate herbicide Vision®. Their studies reported that four hour exposures to sublethal concentrations of Vision did not appear physiologically stressful to juvenile coho salmon, as indicated by secondary stress responses (i.e. increased oxygen consumption, plasma glucose and lactate levels, hematocrit and leukocrit). Rainbow trout exposed for two months at concentrations up to 100mg/L of Vision® exhibited no significant effects in foraging behavior, growth, liver tumors, or gill lesions (Morgan and Kiceniuk 1992). However one study did show immunotoxicity to sublethal levels of glyphosate. At concentrations of 2.8 mg/L, El-Gendy, Aly, and El-Sebae (1998) showed that exposure for 96 hours could significantly alter lymphocyte proliferation, humoral and cell mediated immunity and protein synthesis in tilapia for up to four weeks after exposure.

Assuming the worst case scenario, the highest instantaneous concentration (3.10 mg/L) and the lowest salmonid LC_{50} for Rodeo® (130 mg/L to 210 mg/L; soft water, hard water), the ambient environmental concentration of Rodeo® at the time of application is still approximately 42 to 68 times lower than the 96 hour LC_{50} for Rodeo® exposure to salmonids. Furthermore, the concentration of glyphosate is expected to decrease rapidly due to mixing and dilution in Delta waters after application. Glyphosate will also be adsorbed to particulate matter suspended in the water and onto sediments on the bottom of the Delta waterways. Bacterial degradation will remove glyphosate from the system and metabolize it to simple carbon compounds. The half-life for glyphosate in aquatic environments is on the order of days to weeks (Extoxnet 2001). The environmental fate characteristics of Rodeo® and the application rates used in the WHCP would indicate that the concentration levels of the herbicide achieved in Delta waters should be significantly below the acute toxicity levels of listed salmonids.

As mentioned previously, sublethal effects are of concern. These are the category of effects that are most likely to occur during this program. Sublethal effects are characterized as those that occur at concentrations that are below those that lead directly to death. Sublethal effects produce less obvious effects on behavior, biochemical and/or physiological functions and the histology of the fish. In addition, potential narcosis in exposed fish can lead to negative effects including increased predation and death as described above. Degradation of critical habitat is expected to occur due to decreases in dissolved oxygen, decreases in the invertebrate standing population which reduces the forage base available to the juvenile salmonids and changes in water quality, particularly ambient water temperature due to a decrease in vegetated cover.

Reward®

The estimated instantaneous environmental concentration of Reward® at the application rate used in the WHCP (2.8 lbs. per acre) will be approximately 0.37 ppm diquat. The 96 hour LC_{50} for rainbow trout ranges from approximately 11.5 mg/L (11.2 mg/L, Gilderhus (1967), 12 mg/L, Folmar (1976)) to 21 mg/L (Worthington and Hance 1991). The 8 hour LC_{50} for diquat dibromide is 12.3 mg/L for rainbow trout and 28.5 mg/L for chinook salmon (Pimental 1971). However, studies by Paul *et al* (1994) found that diquat was toxic to larval fish as low as 0.74 ppm (96 hour exposure) and would indicate that early life stages may be much more sensitive to diquat than older fish. Folmar's studies (1976) indicated that rainbow trout did not avoid diquat at concentrations up to 10 mg/L (highest concentration tested), nearly the lethal concentration for this species. The concentration of diquat in the Delta waters is expected to decrease rapidly after initial application due to the extensive adsorption of the compound to suspended particulate matter in the water column and sediment on the bottom. The half-life for diquat dibromide can be as little as 48 hours in water (Extoxnet 2001). However, diquat dibromide may persist for longer period in the bottom sediments. Diquat residues were found 21 days after application in an artificial lake, 1% in the water and 19% adsorbed to sediments (Extoxnet 2001). Diquat that is adsorbed to particulate matter is essentially biologically unavailable to aquatic organisms.

Assuming the worst case scenario, using the highest predicted environmental concentration (0.37 ppm) and the most sensitive LC_{50} (0.74 ppm), the instantaneous diquat concentration is still two times lower than the most sensitive LC_{50} values which are for larval fish. The instantaneous concentration is almost 77 times lower than the published LC50 values for chinook and 31 times lower than those for rainbow trout are. The environmental fate characteristics of Reward® and the application rates used in the WHCP would indicate that the concentration levels of the herbicide achieved in Delta waters should be significantly below the acute toxicity levels of listed salmonids.

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Bioaccumulation of Herbicides

The high water solubility of Weedar® indicates that the active ingredient (2,4-D) is not likely to bioaccumulate in fish tissues, or undergo maternal transfer into developing ovaries and associated eggs. Bluegills and channel catfish absorbed only 0.5 percent of radiolabeled 2,4-D during exposures to 2mg/L of the compound in laboratory studies. The amount of 2,4-D absorbed was maximal after 24 hours of exposure, and did not change significantly for the next 7 days. Bluegills administered 2,4-D via intraperitoneal injection, excreted 90 percent of the dose within 6 hours of treatment (Sikka *et al* 1977). Rainbow trout excrete almost 99 percent of injected 2,4-D in their urine as the unchanged compound, with a half-life of 2.4 hours (Carpenter and Eaton 1983).

There is very low potential for glyphosate, Rodeo®, to bioaccumulate in the tissues of aquatic organisms due to its high water solubility. Furthermore, glyphosate is broken down by microbial actions fairly rapidly, and is subject to photodegradation in the water column. Like Weedar®, Rodeo® strongly adsorbs to particulate matter in the water column and to sediments on the bottom.

There is little bioconcentration of diquat dibromide in fish (Extoxnet 2001). A study on the metabolism and toxicokinetics of diquat dibromide in channel catfish estimated the half-life for diquat to be 35.8 hours (Schultz *et al* 1995), indicating fairly rapid elimination and little potential for bioaccumulation.

The nature of salmonid life history in the Delta also diminishes the likelihood of bioaccumulation of the herbicides applied in the WHCP. Listed species of salmonids are transitory in their use of the Delta, residing for only a few weeks to months in the Delta before emigrating to the ocean.

Removal of Native Submerged and Emergent Aquatic Vegetation

Native submerged and emergent vegetation may be harmed by the application of herbicides during the WHCP. However, NMFS believes that the harm to native vegetation will be temporary, as new colonizing plants take hold in the treated area. Removal of the thick mats of water hyacinth will allow light penetration to submerged plants in areas previously shaded by these mats. Likewise, the floating mats of water hyacinth will not crowd out emergent plants, which smother and abrade the native plants. Treated areas will also allow the native plants the opportunity to re-colonize these areas without competing with the water hyacinth for space and resources. During periods of juvenile salmonid migration, treated areas may not provide the necessary vegetative cover or food resources needed by the fish. Treatment protocols could possibly magnify this impact as adjacent areas could be treated within 48 hours, thereby increasing the areas devoid of aquatic vegetation or having compromised water quality. NMFS believes that these localized effects will reduce the probability of survival of juveniles emigrating through or rearing in the treatment area. Adjacent untreated acreage could be available to provide shelter and foraging for the juvenile salmonids as they move out of the treated area. However, expenditures of valuable metabolic reserves will have to be utilized for swimming to these new areas, making these reserves unavailable for other physiological needs like growth or smoltification. This shift in the utilization of metabolic energy stores has the potential to decrease the fitness and hence the survivability of the juvenile salmonid.

Declines in the Abundance of Invertebrate Food Resources

The chemical compounds proposed for use in the WHCP should not reach toxic levels to invertebrates if they are applied at the labeled rates. Regions of low dissolved oxygen caused by drifting mats of decaying vegetation or smothering of benthic substrate may cause a localized decrease in populations and diversity of invertebrates. This would temporarily affect salmonid foraging success in treated areas. Invertebrates have limited ability to migrate out of the treatment area, and thus are more susceptible to the effects of the dissolved oxygen levels. Following treatment, new populations of invertebrates will re-establish themselves through larval recolonization of the area as soon as habitat conditions are suitable for their growth. Therefore, as a result of the WHCP, portions of the critical habitat for Sacramento River winter-run and Central Valley spring-run chinook salmon as well as Central Valley steelhead will be negatively impacted until water quality is re-established in the treated areas and the native invertebrate species can re-establish themselves in sustainable populations.

Summary of Effects

Based on the foregoing analysis, NMFS anticipates that applications of Weedar®, Rodeo® or Reward® to the waters of the Delta and its tributaries during the 2002 treatment season in an effort to control water hyacinth will not result in acute lethal effects to listed salmonids. In addition, the application of these herbicides is not expected to result in bioaccumulation of these compounds within the tissues of listed salmonids or any of the potential negative consequences that such a bioaccumulation would cause.

However, NMFS expects the application program to have sublethal effects on listed salmonids. Although these sublethal effects will have minimal or undetectable effects on migrating salmonid populations as a whole, they will result in the potential loss of a certain fraction of the migrating population that is exposed to the toxicants or the degraded environmental conditions resulting from the implementation of the WHCP. Though fish should not be present in the cores of the water hyacinth mats, they may be present along the periphery of the mats, utilizing it for cover from overhead predators. Thus, fish may be exposed to herbicides that are applied to the margins of the mat or to herbicides present in the water column directly below the mat or flowing out of the area of application. As stated in Rand (1995), sublethal effects in the listed salmonids can be expected to take the form of physiological, biochemical, behavioral, or histological changes in the exposed fish. These changes may not be immediately lethal, but can eventually cause the fish to develop a lesser level of fitness, thus reducing its chances of survival as compared to unexposed fish.

Furthermore, NMFS believes that the reduction in DO resulting from decaying water hyacinth in treated areas will have a negative effect on the fitness of exposed salmonids in those areas. Even though salmonids should be able to avoid areas of depleted oxygen, if adequate escape routes are maintained as dictated by the operational protocols for the WHCP, they will have to expend metabolic energy to do so. This will result in depleted energy stores that could have been used for other physiological needs, such as growth, smoltification, foraging, or in the case of adults, gonadal maturation.

In addition, fish exposed to herbicides and their adjuvants in the water column, in and adjacent to the application area, may experience narcosis. This physiological state will expose the fish to increased predation risks, due to a loss of equilibrium, swimming ability and predator avoidance behavior.

Indirect effects of the WHCP on critical habitat are due to the anticipated reduction in the invertebrate forage base for juvenile salmonids in the Delta. The reductions in the invertebrate populations are related to the projected decreases in ambient DO in the application areas, and the potential for benthic substrate to be smothered from decaying vegetation as it settles to the bottom. In addition, it is anticipated that shallow water habitats cleared of water hyacinth will experience increased water temperatures due to a decrease in shade from floating vegetative cover. This effect will be beneficial in early spring, as warmer water will enhance invertebrate productivity and salmonid metabolism when other Delta waters are cooler. However, this will also cause these same waters to become too warm as the season progresses, a function of increased heating from solar irradiation. This situation will eventually be attenuated as native vegetation colonizes the treated areas, creating shaded habitat.

The degree to which listed salmonids will be impacted by the implementation of the WHCP is a function of their presence within the action area. The endangered Sacramento River winter-run chinook salmon are anticipated to be exposed during the early spring, when both adults and juveniles are present in the Delta. Adults will have approximately a two month overlap in April and May, when the tail end of the upstream migration is occurring and the WHCP is starting its application schedule. Although winter-run adults will be primarily migrating up the Sacramento River corridor, some fish have been known to stray into the central Delta prior to their upstream migration. Juvenile winter-run chinook salmon are known to utilize the Delta through May and into June, indicating a potential of a three month overlap with the WHCP. Threatened Central Valley spring-run chinook salmon are anticipated to have an exposure of four months for adults (April-July) and three months for fingerlings and fry (April-June). Threatened Central Valley steelhead may have the most exposure as juveniles are migrating through the Delta year round with a peak in the spring and a lesser peak in the fall. The peak of juvenile steelhead outmigration in spring will overlap with approximately two months of the WHCP. Steelhead juveniles are also found year round in the Stanislaus and Tuolumne Rivers where conditions are favorable for rearing. These two rivers have portions of their river channels sited for the WHCP. Adult steelheads are likewise known to be migrating through the Delta year round on either their upstream spawning run, or their downstream emigration to the ocean. The peaks of migration through the Delta for spawning occurs from late fall through early spring, corresponding with increased water flows, but fish continue to pass through the Delta year round. Outmigration of adults occurs after spawning and peaks in late spring and early summer, during the WHCP application period.

Decreased levels of DO, prey abundance, and increased ambient water temperatures are expected to be short-term effects as are the effects of narcosis and most aspects of the sublethal effects. Overall, these effects, although adversely impacting some individual fish, are not expected to reduce the numbers, reproduction or distribution of the listed species to a degree that would appreciably reduce their likelihood of survival and recovery in the wild. Furthermore, the water hyacinth control program is not expected to alter or destroy the functioning of critical habitat within the action area.

VI. CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR 402.02 as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." Future federal actions are not considered in this Opinion because they require separate consultations pursuant to section 7 of the ESA. Ongoing impacts identified in the Environmental Baseline section of this opinion are expected to continue at current rates.

Cumulative effects on the Central Valley spring-run chinook salmon and Central Valley steelhead designated critical habitat include the impacts of point and non-point source chemical contaminant discharges. These contaminants include numerous pesticides and herbicides associated with discharges related to agricultural and urban activities. Implicated as potential sources of mortality for salmon and steelhead, these contaminants may adversely affect salmonid reproductive success and survival rates. Migration corridors and refugia areas may also be affected if lost or made unavailable due to toxic substances.

Additional cumulative effects may result from future non-Federal diversions of water that may entrain adult or juvenile fish or that may decrease outflows incrementally. Water diversions through intakes serving numerous small, private agricultural lands and duck clubs in the Delta, upstream of the Delta, and in Suisun Bay contribute to these cumulative effects. These diversions also include municipal and industrial uses, as well as providing water for power plants. State or local levee maintenance may also destroy or adversely modify critical habitat by disturbing migration corridors or rearing habitat and resuspending contaminants into the water.

The spread of exotic species may occur when levees are breached or when separated creeks or river systems are reconnected during various projects. Several exotic species may potentially adversely affect salmon and steelhead, including the Asian clam (*Potamocorbula amurensis*) and three non-native species of euryhaline copepods. The Asian clam potentially plays an important role in affecting the phytoplankton dynamics in the estuary. The exotic copepods may displace native species and at least one species of copepods (*Sinocalanus doerri*) is difficult for larval fishes to catch because of its fast swimming and effective escape response. Reduced feeding efficiency and ingestion rates weaken and slow the growth of young fish and make them more vulnerable to starvation and predation.

Other cumulative effects include wave action and prop wash in Delta waterways caused by increased boating activity. This potentially degrades riparian and wetland habitat by eroding channel banks, thereby causing an increase in siltation and turbidity. Wakes and prop wash also churn up benthic sediments thereby resuspending contaminated sediments and increasing turbidity and degrading areas of submerged vegetation. This in turn reduces habitat for the invertebrate forage base required for the survival of juvenile salmonids. Increased boat operations in the Delta will also result in more contamination from the operation of engines on powered craft entering the water bodies of the Delta. The Delta region, which includes portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus and Yolo counties, is expected to increase its population by nearly 3 million people by the year 2020 (California Commercial, Industrial and Residential Real Estate Services Directory 2002). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, increasing both water use and stormwater runoff and introducing unregulated pesticides and herbicides as well as nutrients into the environment through domestic and industrial applications. Natural gas development and production in the Delta can alter watershed habitat for pipeline alignments and may introduce pollutants into the Delta in the event of a spill. Agricultural practices in the Delta may reduce riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. Unscreened agricultural diversions throughout the Delta entrain all life stages of listed fish. Grazing activities from diary and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the Delta.

VII. CONCLUSION

Based on the best available scientific and commercial information, the current status of the Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon, and Central Valley steelhead, the environmental baseline, cumulative effects, and the effects of the proposed action, it is NMFS' biological opinion that the proposed WHCP for the 2002 treatment season is not likely to jeopardize the continued existence of Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon, or Central Valley steelhead, or result in the destruction or adverse modification of their designated critical habitat.

VIII. INCIDENTAL TAKE STATEMENT

Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to engage in any such conduct. NMFS further defines harm to include any act that actually kills, or injures fish or wildlife and emphasizes that such acts may include significant habitat modification or degradation that significantly impairs essential behavioral patterns including breeding, spawning, rearing, migration, feeding or sheltering. Incidental take is defined as take of a listed animal species that results from, but is not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7 (b) (4) and section 7(o) (2), taking that is incidental to, and not intended as part of, the proposed action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary. They must be implemented by the USDA-ARS so that they become binding conditions of any grant or permit issued to the DBW, as appropriate, for the exemption in section 7(o)(2) to apply. The USDA-ARS has a continuing duty to regulate the activity covered in this Incidental Take Statement. If the USDA-ARS: (1) fails to assume and implement the terms and conditions of the Incidental Take Statement, and/or (2) fails to require the DBW to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, USDA-ARS and the DBW must report the progress of the action and its impact on the species to NMFS as specified in this Incidental Take Statement (50 CFR § 402.14 (i)(3)).

This Incidental Take Statement is applicable to the operations of the Water Hyacinth Control Program project as described in the Biological Assessment submitted on February 9, 2001, and the proposed operations protocol described in the NPDES permit from the Water Quality Control Board to the DBW. This Incidental Take Statement shall cover the operations of the WHCP for the 2002 application season.

A. Amount or Extent of Take

The National Marine Fisheries Service anticipates that the Water Hyacinth Control Program (WHCP) operations will result in take of listed salmonids. This will primarily be in the form of "harm" to salmonids by impairing essential behavior patterns as a result of sublethal effects resulting from exposure to the applied herbicides, and reductions in the quality or quantity of their critical habitat. Those impingements to the listed salmonid's critical habitat will be primarily the result of decreased DO levels affecting the foraging success of juvenile fish, either through reallocation of the fish's metabolic reserves or the declining availability of the invertebrate forage base. Furthermore, alterations in ambient water temperatures in shallow water habitats following water hyacinth treatments may have both negative and positive effects on salmonid utilization of these habitats, as described previously. In addition, NMFS believes that some juveniles may be directly killed, injured or harassed in the application of herbicides or as a result of boat operations in shallow water habitats during the treatment process, based on the fish's presence in the immediate vicinity of these activities.

The take of listed salmonids will be difficult to detect since the actual observation of a dead or injured salmon is unlikely, given the physical parameters of the Delta and the density of water hyacinth mats visually obscuring any activity below the mats. The impacts of the DBW operations will result in changes to the quality and quantity of salmonid habitat. These changes are expected to correspond to injury to, or in reductions in the survival of, juvenile and adult salmonids by interfering with essential behaviors such as rearing, foraging for food, migration, and sheltering as described previously under the effects of the action for the WHCP. Since the expected negative alterations in the behavior of juvenile salmonids correlate most closely with the predicted impacts to the salmonid habitat, NMFS is defining the amount or extent of take anticipated in the proposed action in terms of limitations on habitat impacts. NMFS expects that physical habitat impacts will be consistent with the project description in terms of location, scope, and compliance with the proposed minimization and mitigation measures; compliant with the terms and conditions of this Incidental Take Statement; and, within the expected effects of DBW operations as described in this Opinion. Adverse effects to, and incidental take of, listed salmonids are primarily expected during the April 1 through October 15 time period, when herbicides are being applied in the action area.

Anticipated incidental take may be exceeded if the DBW operations are not in compliance with the project description or the terms or conditions of this Incidental Take Statement that address operations in the field, or if effects of DBW operations are exceeded or substantially different than the expected effects described in this opinion.

For example, NMFS anticipates that the DBW operations in 2002 will decrease the amount of DO and available habitat in the Sacramento-San Joaquin Delta. The reduction in ambient DO when salmonids are present is expected to result in a reduction of feeding and rearing success, and additional energy being expended in the avoidance of treated areas and movement to more suitable habitats. This redirection of metabolic energy stores to extended swimming activities compromises the fish's ability to store energy for growth, avoidance of predators, and to carry out physiological processes such as smoltification or immune response to diseases. Reductions in metabolic energy stores places additional stress on the fish and leads to a reduction in fitness and survivability.

Discharges of the herbicides 2,4-D, glyphosate or diquat along channel margins in order to control water hyacinth infestations are expected to decrease the amount of available shallow water habitat in these channel margins due to reduced DO levels. Reductions in surface coverage of aquatic vegetation will lead to increases in shallow water temperatures, which will then decrease the DO. This condition is further exacerbated by the increased oxygen demand of decaying vegetation caused by the herbicidal applications. These physical alterations in the habitat are expected to result in sub-lethal physiological stresses, leading to reduced fitness and survival, early termination of smoltification, and delays in migration. DBW operations are expected to result in reductions of DO levels, which still must meet the standards of the NDPES permit. Therefore, changes that exceed these parameters, i.e., DO less than 5.0 mg/L in Delta waters, would exceed the anticipated levels of incidental take.

B. Reasonable and Prudent Measures

NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize incidental take of Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon, or Central Valley steelhead caused by the actions of the DBW.

1.) Measures shall be taken to reduce impacts to juvenile Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon and Central Valley steelhead from chemical control treatment and/or monitoring activities.

2.) Measures shall be taken to reduce the impact of DBW water hyacinth control program boating operations on Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon, and Central valley steelhead.

3.) Measures shall be taken to monitor DBW water hyacinth control operations and Delta hydrologic conditions.

C. Terms and Conditions

The USDA-ARS is responsible for DBW compliance with the following non-discretionary terms and conditions that implement the reasonable and prudent measures described above:

1. Measures shall be taken to reduce impacts to juvenile Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon and Central Valley steelhead from chemical control treatment and/or monitoring activities

Terms and Conditions:

A. Chemical controls for the WHCP in the Delta shall not be applied before April 1, 2002 for the 2002 control season in any portion of the action area. Areas of application available to the WHCP as of April 1, 2002 are:

i. The San Joaquin River upstream of the confluence with the Merced River (Hills Ferry) and associated sloughs and canals in Merced and Fresno counties south of the confluence of the Merced and San Joaquin Rivers.

ii. Delta east side sloughs that have minimal current and unsuitable salmonid habitat:

Fourteenmile Slough east of Shima Tract
Pixley Slough
Rio Blanco Tract
Portions of White's and Disappointment Slough east of Honker Cut
Sycamore Slough
Hog Slough
Beaver Slough
Lost Slough
Snodgrass Slough above the Delta Cross Channel
Stone/ Beach Lakes Area

Areas available to herbicide application as of April 15, 2002 are portions of the South Delta that are within the region bounded by the placement of the four South Delta Temporary Barriers. These include portions of Old River, Middle River, Paradise Cut, Salmon Slough, Tom Paine Slough, Sugar Slough, Grant Line, Fabian, and Bell Canals.

Remainder of the action area after June 1, 2002, or when IEP data indicates that the pulse of migrating salmon has moved through the Delta. If IEP data shows that fish are still present in these reaches, spraying activities may be suspended upon the discretion of NMFS personnel.

B. Chemical controls for the WHCP shall not be applied after October 15, 2002 for the 2002 control season.

C. Any winter-run chinook salmon, spring-run chinook salmon, and steelhead trout mortalities found at or in the vicinity of a treatment site shall be collected, fork length measured and placed in a whirl-pak bag. The bag will be labeled with the time, date, location of capture, and a description of the near-shore habitat type and water conditions and frozen. NMFS, Sacramento office shall be notified as soon as possible of any mortalities at 916-930-3600 and a representative of NMFS will collect the specimen.

D. DBW staff and their agents must follow all Federal and State laws applicable to the use of the herbicides and adjuvants and apply them in a manner consistent with the product labeling, the NPDES permit, Proposed Action, and determinations from the California Department of Pesticide Regulation.

E. Fish passage shall not be blocked within treatment areas. Protocols shall be followed to ensure that WHCP operations do not inhibit passage of fish in each area scheduled for treatment or exceed limitations on contiguous treated acreage.

F. The DBW will provide a copy of each week's Notice of Intent (NOI) to Jeff Stuart, Fishery Biologist, Protected Resources Division, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814, by the Friday prior to the treatment week. This notification will include the sites scheduled for treatment and a contact person for those sites.

G. Jeff Stuart will be the appointed NMFS representative on the Water Hyacinth Task Force (Task Force), and provide technical assistance to the Task Force along with carrying out the duties of a Task Force member. As part of the WHCP task Force, the NMFS representative will be active in guiding decisions on prioritizing treatment sites in regards to the presence of salmonids.

2. **Measures shall be taken to reduce the impact of DBW water hyacinth control program boating operations on designated critical habitat of Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon, and Central Valley steelhead.**

Terms and Conditions:

A. USDA-ARS and DBW shall comply with the receiving water limitations of the NPDES permit issued for the WHCP in regards to oils, greases, waxes, floating material, or suspended material derived from the operation of program vessels or application activities

B. The USDA-ARS and DBW shall ensure that any mixing of chemicals, or disinfecting and cleaning of any equipment shall be done in strict accordance with the operational protocols of the WHCP and that all equipment is in working order prior to engaging in spray activities, including the operation of the program vessels.

C. Operation of program vessels in shallow water habitats shall be done in a manner that causes the least amount of disturbance to the habitat. Operational procedures for vessels in these habitats should minimize boat wakes and prop wash.

D. Operation of program vessels shall minimize or avoid to the greatest practicable extent dislodging portions of existing water hyacinth mats that can drift into other areas. This avoids creating the low DO water conditions in a new area that is commonly associated with the water hyacinth mat and the colonization of new areas in the action area.

3. Measures shall be taken to monitor DBW water hyacinth control operations and Delta hydrologic conditions.

Terms and conditions:

A. The USDA-ARS shall ensure that the DBW follows a comprehensive monitoring plan designed to collect project operational information. This monitoring plan shall be submitted to Jeff Stuart, NMFS-Sacramento Field Office, for review and approval upon its immediate completion and prior to its implementation. The monitoring plan shall have at a minimum, data on water temperatures, dissolved oxygen, and chemical concentrations in the application areas. Chemical concentrations shall have at a minimum, a pre and post-application water sample taken at the furthest down current site of the application zone. Additional tests, if required by other federal and state agencies, shall be conducted and the information made available to NMFS. The results of this monitoring program will be used to determine if the DBW is affecting winter-run chinook salmon, spring-run chinook salmon, or steelhead trout to an extent not previously considered.

B. The USDA-ARS, in coordination with the DBW, shall provide monthly monitoring reports of hydrologic conditions and the amounts of chemical discharges to Jeff Stuart, NMFS-Sacramento Field Office. These reports shall also include information on the following parameters:

i. Pretreatment and post-treatment measurements on chemical residues, pH and turbidity levels as well as water temperatures and dissolved oxygen concentrations at selected sites in the Delta, including at least one site in the Stockton Deep Water Channel where historical oxygen depletion occurs. These sites are to be determined by DBW as part of their NPDES permit conditions and will be conducted three times during the application season. Inclusion in the monthly reports will occur when applicable.

ii. Daily receiving water temperatures and dissolved oxygen levels and resultant changes in those conditions resulting from WHCP operations during each month.

iii. Amounts and types of herbicides and adjuvants applied at each site.

iv. Pre-treatment and post-treatment conditions of treated sites to assess the efficacy of treatment and any effects of chemical drift on downstream habitats immediately adjacent to the treated sites.

v. Operational status of equipment and vessels, including repairs and spraying equipment calibrations as needed.

C. The USDA-ARS, in coordination with the DBW, shall summarize the above monthly reports into an annual report of the DBW project operations, monitoring measurements and Delta hydrological conditions for the previous treatment year for submission to NMFS by January 31, 2003. The annual report of DBW operations shall also include:

i. A description of the total number of winter-run and spring-run chinook salmon or steelhead taken, the manner of take, and the dates and locations of take, the condition of the winter-run chinook salmon, spring-run chinook salmon, or steelhead trout taken, the disposition of fish taken in the event of mortality and a brief narrative of the circumstances surrounding the take of the fish. This report shall be sent to the addresses given below.

ii. Listed salmonids or other fish species that are observed to be behaving in an erratic manner shall be reported (see appendix A).

D. All monthly reports shall be submitted by mail or Fax to:

NMFS-Sacramento Field Office
Attn: Jeff Stuart
650 Capitol Mall, Suite 8-300
Sacramento, California, 95814
Fax: (916) 498-6697

IX. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary measures that the USDA-

ARS can take to minimize or avoid adverse effects of a proposed action on a listed species or critical habitat or regarding the development of pertinent information. In addition to the terms and conditions of the Incidental Take Statement, NMFS provides the following conservation recommendations that would reduce or avoid adverse impacts on the Sacramento River winter-run chinook salmon, the Central Valley spring-run chinook salmon and the Central Valley steelhead.

1. The USDA-ARS should encourage alternative non-chemical controls of water hyacinth and other non-native invasive vegetation in the Sacramento/San Joaquin Delta and its tributaries.

2. The USDA-ARS should support, through research and other means, studies that evaluate juvenile salmonid rearing and migratory behavior in the Sacramento/San Joaquin Delta. These studies may include the effects of various chemical control operations and non-point source chemicals on the survival and behavior of juvenile salmonids, including chronic and sublethal effects at concentrations below acute toxicity and the effects of water hyacinth removal on the functioning of aquatic habitat including designated salmonid critical habitat.

3. USDA-ARS is encouraged to explore CALFED partnership programs to help control water hyacinth in the Delta, including re-vegatation programs with native plants, invasive non-native species control programs including public education, and limitations on the sale and handling of ornamental plants that can become invasive species in the wild through regulations or policy.

X. REINITIATION OF CONSULTATION

Reinitiation of formal consultation is required if there is discretionary federal involvement or control over the action and if (1) the amount or extent of taking specified in any incidental take statement is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the action is subsequently modified in a manner that causes an affect to the listed species that was not considered in the biological opinion; or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

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Enclosure 2.

Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA)

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS[1]

The Pacific Fisheries Management Council has delineated an EFH designation for the Pacific salmon fishery (PFMC, 1999). Species within the action area of the proceeding biological opinion, which requires EFH consultation, are the chinook salmon (*Oncorhynchus tshawytscha*). The U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS), in cooperation with the State of California Department of Boating and Waterways (DBW), must provide a detailed response in writing describing the measures proposed by State of California Boating and Waterways for avoiding, mitigating, or offsetting the impacts of the project on EFH.

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

The geographic extent of freshwater essential fish habitat (EFH) for the Pacific salmon fishery is proposed as waters currently or historically accessible to salmon within specific U.S. Geological Survey hydrologic units (Pacific Fisheries Management Council 1999). For the Delta region, the aquatic areas identified as EFH for chinook salmon are within the hydrologic unit maps numbered 18050001, 18020109, 18040002, 18040003, and 18040004. The upstream extent of Pacific salmon EFH in the proposed action area is to the first impassable dam or barrier on the tributaries that are accessible to anadromous fish.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat, Awaters@ includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; Asubstrate@ includes sediment, hard bottom, structures underlying the waters, and associated biological communities; Anecessary@ means habitat required to support a sustainable fishery and a healthy ecosystem; and Aspawning, breeding, feeding, or growth to maturity@ covers a species= full life cycle. For the Sacramento-San Joaquin Delta, the aquatic areas that may be identified as EFH for salmon are within the hydrologic unit maps numbered 18050001, 18020109, 18040002, 18040003, and 18040004 encompassing the Sacramento-San Joaquin Delta and its associated tributaries, including the San Joaquin River up to the confluence with the Merced River.

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[1]The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) set forth new mandates for the National Marine Fisheries Service (NMFS) and federal action agencies to protect important marine and anadromous fish habitat. Federal action agencies which fund, permit, or carry out activities that may adversely impact EFH are required to consult with NMFS regarding potential adverse effects of their actions on EFH, and respond in writing to NMFS "EFH Conservation Recommendations."

Historically, the Sacramento-San Joaquin Delta, has served as a migratory route for immigrating adult winter, spring, and fall-run chinook salmon (*Oncorhynchus tshawytscha*) to their spawning habitat, and for rearing and emigration of juveniles returning to the ocean (Yoshiyama et al. 1996). Within the Central Valley of California, populations of winter and spring-run chinook salmon have declined significantly as a result of habitat degradation due to dams, water diversions, and placer mining, as well as past and present land-use practices. The fall-run has been reduced, however to a lesser extent than the winter-run and spring-runs (Myers 1998). Recent estimates find that fall-run chinook have declined between 85 percent to 90 percent (Rich and Loudermilk 1991; USFWS 1995) of the population levels which existed in the 1940's. Fall-run chinook spawning population estimates from the Stanislaus, Tuolumne and Merced Rivers from 1974 to 1991 show both rising and descending trends lasting for several years (Kano 1996, 1998). Factors limiting salmon populations include low instream flows, high water temperature, reversed flows in the Delta (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversion, predation (especially by warm-water fish species), and lack of rearing habitat (Kondolf et al., 1996a, 1996b). In addition to direct losses caused by the entrainment or entrapment of fish at diversions, withdrawals of water affect both the total volume of water available to salmon and their prey, as well as the seasonal distribution of flows. Consequently, migration may be altered, changes to sediment and large woody debris transport and storage, altered flow and temperature regimes, pollution, and water level fluctuations may result (Dettman et al. 1987; CACSST 1988).

LIFE HISTORY AND HABITAT REQUIREMENTS

General life history information for fall-run chinook salmon is summarized below. Information on Sacramento River winter-run and Central Valley spring-run chinook salmon life histories are summarized in the associated Biological Opinion for the described project (enclosure 1). Further detailed information on chinook salmon ESUs are available in the NMFS status review of chinook salmon from Washington, Idaho, Oregon, and California (Myers et al. 1998), and the NMFS proposed rule for listing several ESUs of chinook salmon (NMFS 1998).

Central Valley fall-run chinook enter the Sacramento and San Joaquin Rivers from July through April and spawn from October through December (USFWS 1998) with spawning occurring from October through December. Peak spawning occurs in October and November (Reynolds et al. 1993). Chinook salmon spawning generally occurs in swift, relatively shallow riffles or along the edges of fast runs at depths greater than 6 inches, usually 1-3 feet to 10-15 feet. Preferred spawning substrate is clean loose gravel, Gravels are unsuitable for spawning when cemented with clay or fines, or when sediments settle out onto redds reducing intergravel percolation (NMFS 1997).

Egg incubation occurs from October through March, and juvenile rearing and smolt emigration occurs from January through June (Reynolds et al. 1993). Shortly after emergence from their gravel nests, most fry disperse downstream towards the Delta and estuary (Kjelson et al. 1982). The remainder of fry hide in the gravel or station in calm, shallow waters with bank cover such as tree roots, logs, and submerged or overhead vegetation. These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-

June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, submerged aquatic vegetation, logs, riparian vegetation, and undercut banks provide food, shade and protect juveniles and smolts from predation. These smolts generally spend a very short time in the Delta and estuary before entry into the ocean.

In contrast, the majority of fry carried downstream soon after emergence are believed to reside in the Delta and estuary for several months before entering the ocean (Healey 1980, 1982; Kjelson et al. 1982). Principal foods of chinook while rearing in freshwater and estuarine environments are larval and adult insects and zooplankton such as *Daphnia,* flies, gnats, mosquitoes or copepods (Kjelson et al. 1982), stonefly nymphs or beetle larvae (Chapman and Quistdorff 1938) as well as other estuarine and freshwater invertebrates. Whether entering the Delta or estuary as fry or juvenile, fall-run chinooks depend on passage through the Sacramento-San Joaquin Delta for access to the ocean.

II. PROPOSED ACTION.

The proposed action is described in Part II of the associated Biological Opinion for the endangered Sacramento River winter-run chinook salmon ESU, threatened Central Valley spring-run chinook salmon ESU and their critical habitats.

III. EFFECTS OF THE PROJECT ACTION

The Sacramento-San Joaquin Delta is of vital importance to adult and juvenile chinook salmon as a major corridor for migration. In addition, the majority of chinook salmon rely on the Delta and estuary for rearing that will prepare them for entry and survival in the ocean. As such, it functions as a portion of the habitat necessary to support a sustainable population. The presence and operation of DBW=s Water Hyacinth Control Program can interrupt the EFH habitat functions by reducing the quantity and quality of rearing, feeding, migration and sheltering habitat.

Juvenile salmon often enter the Delta before they are physiologically able to enter salt water, and rear there several months before migrating to the ocean. The proposed April 1 through October 15, 2002 implementation of water hyacinth control measures would occur during the upstream migration of adult chinook salmon, and during the emigration of fry and juvenile chinook salmon.

It is anticipated that DBW operations will adversely impact the zooplankton and benthic invertebrate prey base following chemical application. This is primarily due to reductions in the dissolved oxygen concentration in the treated waters, as well as potential acute and sublethal effects due to the applied chemicals. These impacts may result in reduced feeding and rearing success for juvenile fish that have to cover a wider foraging area to capture enough prey to meet their caloric needs, thus reducing the stores of reserve energy available to the fish. Declines in a fish's condition can result in increased morbidity and mortality. Sublethal effects can impinge on behavioral (e.g., swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological (e.g., growth, reproduction, and development), biochemical (e.g., blood enzyme and ion levels), and histological characteristics of listed fish. Degradation of water quality parameters such as DO and temperature in treated areas can potentially cause "barriers" which impede juvenile and adult migration through the action area. Water quality may be affected by increasing temperatures and chemical pollutants, and decreasing dissolved oxygen levels. These actions are expected to reduce rearing and feeding opportunities for juvenile chinook salmon by removing or otherwise destroying rearing habitat and potentially increase pollution input from boat operations. Lastly, the monitoring of listed fish species, such as delta smelt, may result in the incidental capture of fall-run chinook salmon.

The Water Hyacinth Control Program is anticipated to result in the long-term control of water hyacinths and, according to DBW, ultimately open up rearing habitat and migration routes for the chinook salmon.

IV. CONCLUSION

Upon review of the effects of the DBW=s Water Hyacinth Control Program, NMFS believes that the operation of the Water Hyacinth Control Program adversely affect the EFH of fall-run chinook in the project area of the Sacramento-San Joaquin Delta.

V. EFH CONSERVATION RECOMMENDATIONS

NMFS recommends that Reasonable and Prudent Measures Numbers 1, 2, and 3 and their respective Terms and Conditions listed in the Incidental Take Statement prepared for the Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon and Central Valley steelhead ESUs in the preceding Biological Opinion be adopted as EFH Conservation Recommendations. In addition, three additional EFH Conservation Recommendations are provided below. These recommendations are provided as advisory measures.

1. The USDA-ARS, DBW and their agents should report annually to NMFS on the amount of herbicide applied onto each treated region of the Delta and habitat islands, as well as the estimated acreage of treated water hyacinth in the Delta.

2. The USDA-ARS, DBW and their agents should monitor the treated areas and implement adequate control measures to minimize areas of decreased oxygen into the Delta during WHCP chemical control operations.

3. The USDA-ARS, DBW and their agents should report annually on the progress and success of the restoration of the treated acres of shallow water habitat, and its benefits to chinook salmon.

VI. STATUTORY REQUIREMENTS

The Magnuson-Stevens Act and Federal regulations (50 CFR ' 600.920) to implement the EFH provisions of the MSFCMA require federal action agencies to provide a written response to EFH Conservation Recommendations within 30 days of their receipt. A preliminary response is acceptable if final action cannot be completed within 30 days. Your final response must include a description of measures proposed to avoid, mitigate, or offset the adverse impacts of the activity. If your response is inconsistent with our EFH Conservation Recommendations, the USDA-ARS must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects.

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Attachment 1.

Physical Effects and Avoidance Behavior in Fish due to Chemical Contamination

"The death of some organisms, such as mysids and larval fish, is easily detected because of a change in appearance from transparent or translucent to opaque. General observations of appearance and behavior, such as erratic swimming, loss of reflex, discoloration, excessive mucus production, hyperventilation, opaque eyes, curved spine, hemorrhaging, molting, and cannibalism, should also be noted in the daily record" (Section 10.1.3, Weber, 1993).

Overt Signs of Fish Distress

I. Respiratory stress - hyperventilation.
II. Disorientation in swim pattern, induced by narcosis.*
III. Mucus secretions from gills, mouth distension or 'cough' reflex.

Behavioral Response

I. Actively move from area of contamination.
II. Reduced swimming rate.
III. Passively be carried away from the area (some chemical impact to fish).
IV. Lethal concentration causes fish mortality. Fish rise to water surface, ventral-side up, with distended belly, no respiration, rigor mortis.

*Narcosis: a general, nonspecific, reversible mode of toxic action that can be produced in most living organisms by the presence of sufficient amounts of many organic chemicals. Effects result from the general disruption of cellular activity. The mechanism producing this effect is unknown, with the main theories being binding to proteins in cell membranes and 'swelling' of the lipid portion of cell membranes resulting from the presence of organic chemicals. Hydrophobicity dominated the expression of toxicity in narcotic chemicals.

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